Re-vitalising Energy Transition in Touristic Islands

Pilot Descriptions and Results

Deliverable 3.2 - Public

Lead beneficiary: MAG

Co-funded by the European Union

History of Changes

Version	Date	Authors
V0.1	04/09/2024	Samuele Baroni, Panagiotis Karkazis
V1.0	31/01/2025	UPV

List of Acronyms

Acronym	Meaning
AP	Action Plan
AHP	Analytical Hierarchical Process
BAU	Business As Usual
CA	Consortium Agreement
CoM	Covenant of Mayors
DHW	Domestic Hot Water
D3.1	GENERA deliverable on ET Monitoring tools description
D4.1	GENERA deliverable on road-mapping needs and island-specific recipes
EP	Energy Planning
ET	Energy Transition
EU	European Union
EV	Electrical Vehicle
GA	Grant Agreement
LASM	Local Authorities Support Managers
SCOP	Seasonal Coefficient Of Performance
SE	Sustainable Scenario
SECAP	Sustainable Energy and Climate Action Plan
SEER	Seasonal Energy Efficiency Ratio
SIMESEN	Simulation Energy Scenarios
SMEs	Small and medium-sized enterprises
UPV	Polytechnical University of Valencia
WP	Work Package

Executive Summary

This document has been developed as part of **LIFE21-CET-LOCAL-GENERA** project, funded by European Climate, Infrastructure and Environment Executive Agency - LIFE Project Grants, under **Grant Agreement No. 101077073**.

It corresponds to Work Package 3 (WP3) – *Energy Transition Monitoring Tools* and to Deliverable D3.2 – *Pilots Description and Results*. This deliverable includes the information gathered through the activities *T.3.5 Validation of the Monitoring tools: pilots and benchmarking.*

This document focuses on the validation of the tools created by the GENERA project to check that the Energy Transition package is operational and meets the requirements of the users. For this purpose, a pilot test will be carried out in different municipalities located in tourist islands mainly in the Mediterranean: Sant Antoni de Portmany (Ibiza, Spain), El Rosario (Tenerife, Spain), Stintino (Sardinia, Italy), Halki, Rhodes and Nisyros (Greece).

The GENERA tool consists of modules discussed in the deliverable *Deliverable D3.1 - GENERA ET Monitoring tools description*: 1.National Energy Context Definition, 2.Knowledge Database, 3.Inference Module and 4.Multicriteria Decision Making Module. These tools together constitute the Energy Transition Package that will be used in this document to provide the information for the pilots.

This deliverable proposes updates and improvements to the tools that can be implemented in the future, as well as conclusions on the results obtained.

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1. Overview

1.1. Purpose and Scope

The main objective of this deliverable is to provide a report with the tools generated through the GENERA project, their application to different pilots and the results gathered through their application for the subsequent improvement of the tools for the Energy Transition.

Specific key objectives in GENERA include providing tools to identify the energy context of the islands at the national level and creating a municipal roadmap appropriate to the municipal casuistry of the islands. This deliverable is based on the information collected in WP2, WP3 and WP4 that has been processed together with a desk study and different meetings held with municipalities. All this has facilitated the implementation of the tool. The content of this report gathers specific information of task *T.3.5 Validation of the Monitoring tools: pilots and benchmarking*. The objective of this document is to show the application of the tools in the different pilots, and to serve as an example for future implementations.

1.2. Structure of the deliverable

The document is structured in four chapters in addition to this first one, which is the general overview:

Chapter 2 – Genera Tools updates

This chapter is focused on showing the main characteristics and specifications of the modules proposed by the GENERA project:

1 - Definition of the National Energy Context

2 - Knowledge Database

3 –Inference Module

4 - Multicriteria Decision-making Module.

Chapter 3 - Pilots Results

Results of a total of six pilots: Sant Antoni de Portmany (Ibiza, Spain), El Rosario (Tenerife, Spain), Stintino (Sardinia, Italy), Halki, Rhodes and Nisyros (Greece).

Chapter 4 – Conclusions

This chapter highlights the main conclusions of this deliverable.

2. Genera Tools updates

According to GENERA's objectives, firstly, it aims to establish a framework of energy transition measures for the implementation of climate agendas in tourist municipalities, assisting them all the way from the creation of the agenda to the implementation of the measures and citizen engagement, in accordance with the Clean Energy Transition Agendas of the EU Islands and the Covenant of Mayors.

In addition, it is intended to promote the implementation of energy monitoring measures to quantify the evolution of the process. The methodology proposed by the GENERA project is as follows according to figure 1:

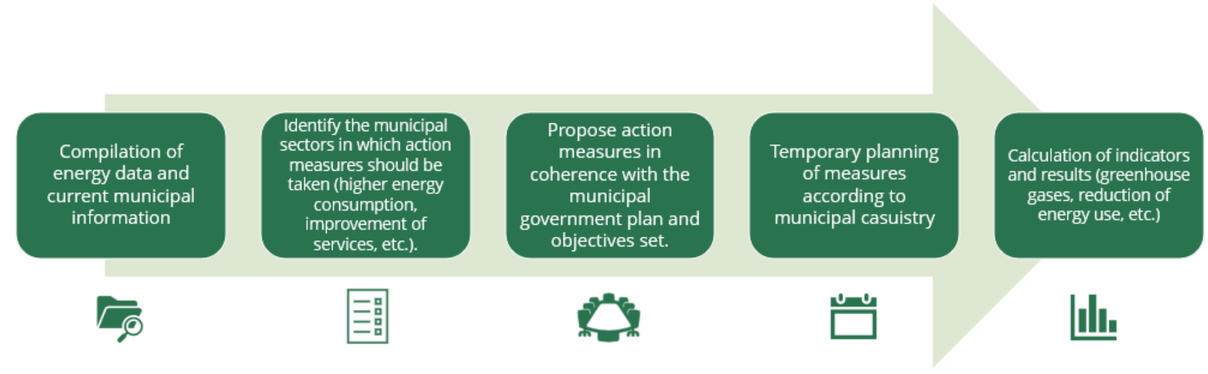


Figure 1. Methodology proposed by the GENERA project for the creation of a SECAP

In the previous deliverable D3.1 a first approach to the GENERA tools was made in order to create a specification sheet that included the necessary and required information for each of the modules. As the project has progressed, these tools have changed and have been modified to include new functionalities. However, these tools are subject to changes and improvements as long as they facilitate their use by policy makers, city council technicians and other interested parties who require their use.

2.1. Monitoring tools

The GENERA project has created an Energy Transition package (Figure 2) in line with its objectives and the needs identified throughout the project. It is important to have the voice of policy makers to ensure a coherent implementation of the measures, so the last module is an innovative point that will characterize the roadmap.

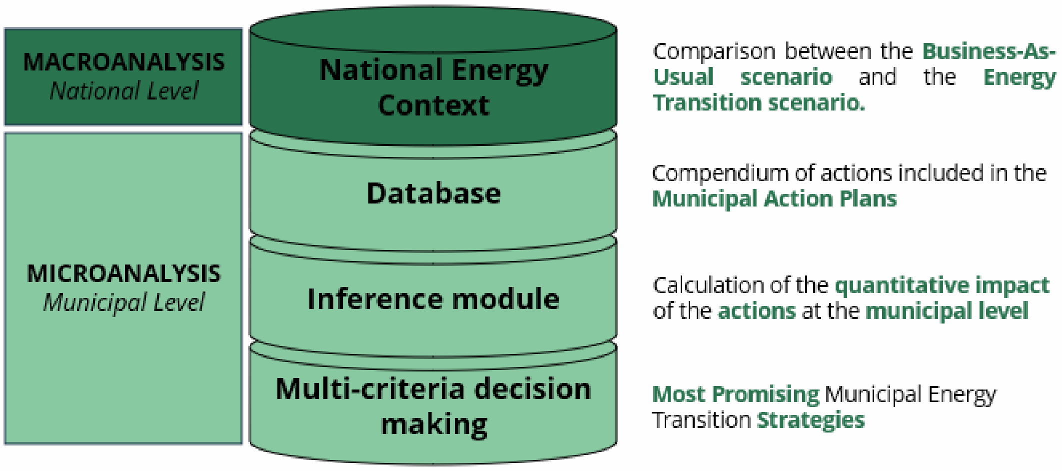


Figure 2. GENERA's Energy Transition Package

The following sections provide a brief overview of the different modules and their functionalities, as well as possible improvements within the energy transition package.

2.1.1. Energy Context Module

This module is designed for Energy Planning (EP) at the national level for the municipality under study, it aims to analyze the alternative ways of energy evolution through the study of different energy scenarios.

The SIMESEN tool (Simulation of Energy Scenarios) was developed at the Institute of Energy Engineering of the Polytechnic University of Valencia (UPV) in 2010 based on the evolution of independent variables that can be defined by predetermined mathematical law, and therefore, no major changes or relevant modifications have been made. This tool makes it possible to determine the evolution of a given energy scenario based on energy demand and the availability of primary energy, in order to subsequently deduce the role that renewable energies could play to make a sustainable scenario possible within a predetermined period of time.

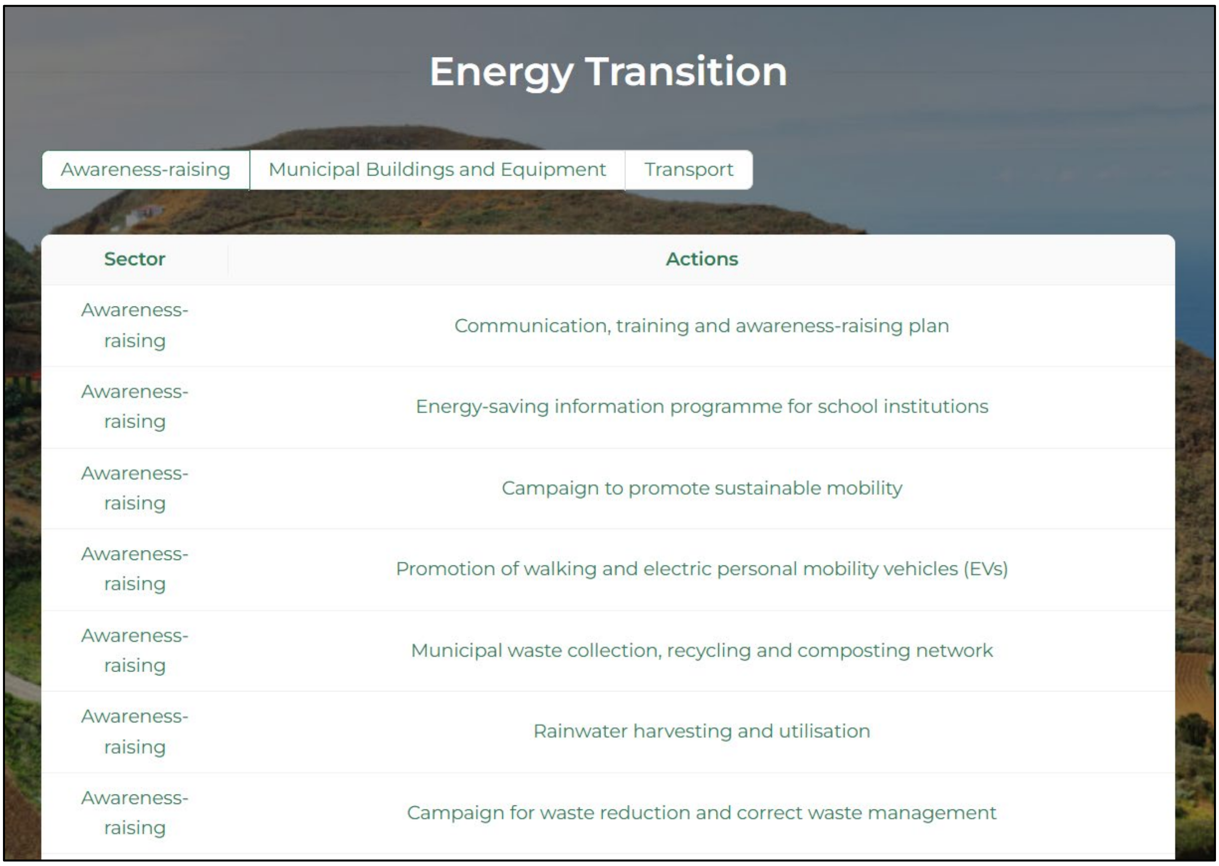
2.1.2. Knowledge Database

This module consists of a repository of existing actions in Municipal Action Plans located on tourist islands in Greece, Italy and Spain. The main actions included in different municipal action plans of the islands were compiled together with the annual energy savings, the annual CO_2 emissions savings and the implementation cost per 1000 inhabitants.

The actions were grouped into the following sectors: awareness, industry, municipal buildings and equipment, and transport.

This repository was integrated into GENERA's Digital Social Platform to make it fully accessible to all public authorities and technicians of municipalities that require it. Therefore, the updates related to this module are presented in the following figures:

Figure 3. Access to the Energy Transition Tool: Database



Sector	Actions
Awareness-raising	Communication, training and awareness-raising plan
Awareness-raising	Energy-saving information programme for school institutions
Awareness-raising	Campaign to promote sustainable mobility
Awareness-raising	Promotion of walking and electric personal mobility vehicles (EVs)
Awareness-raising	Municipal waste collection, recycling and composting network
Awareness-raising	Rainwater harvesting and utilisation
Awareness-raising	Campaign for waste reduction and correct waste management

Figure 4. List of actions in the GENERA Database

Figure 5. Information included within each action in the list of actions in the GENERA Database

2.1.3. Inference Module

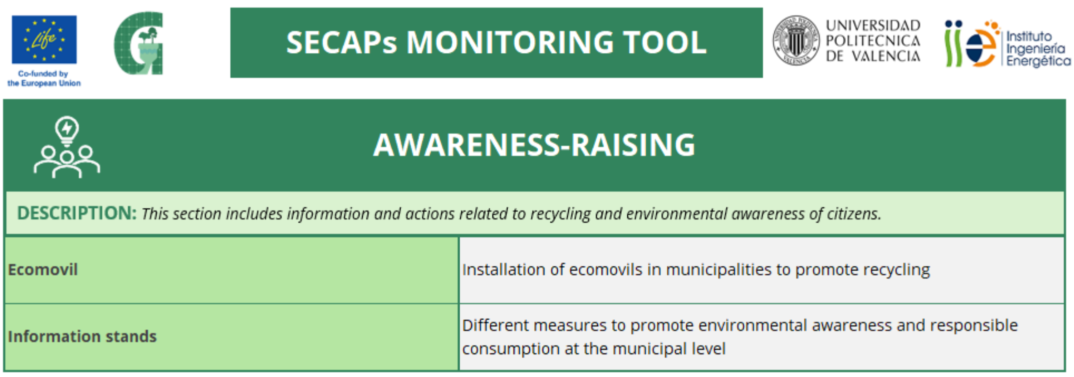
This module provides the user with a calculation method to obtain the impact of the implementation of actions similar to those offered in the Knowledge Database in terms of energy and emissions, appropriate to the municipality. For this purpose, a method for calculating energy savings and emissions has been developed for each of the proposed actions. The actions have been organized according to the sections contained in the DataBase module, and some updates have been made with respect to the information that was included in the D3.1 report:

2.1.3.1. Section 1: Awareness-Raising

In this section, the same actions previously established are maintained:

- Installation of a municipal ecomovil
- Municipal information stands

These are the main actions that were proposed and have been implemented in the GENERA tool in the Inference module:



SECAPs MONITORING TOOL

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AWARENESS-RAISING	
DESCRIPTION: *This section includes information and actions related to recycling and environmental awareness of citizens.*	
Ecomovil	Installation of ecomovils in municipalities to promote recycling
Information stands	Different measures to promote environmental awareness and responsible consumption at the municipal level

Figure 6. Actions implemented in the awareness-raising section of the toolkit

Following the calculation procedure discussed in report D3.1, the calculation of energy and CO_2 savings for each of the measures is shown below.

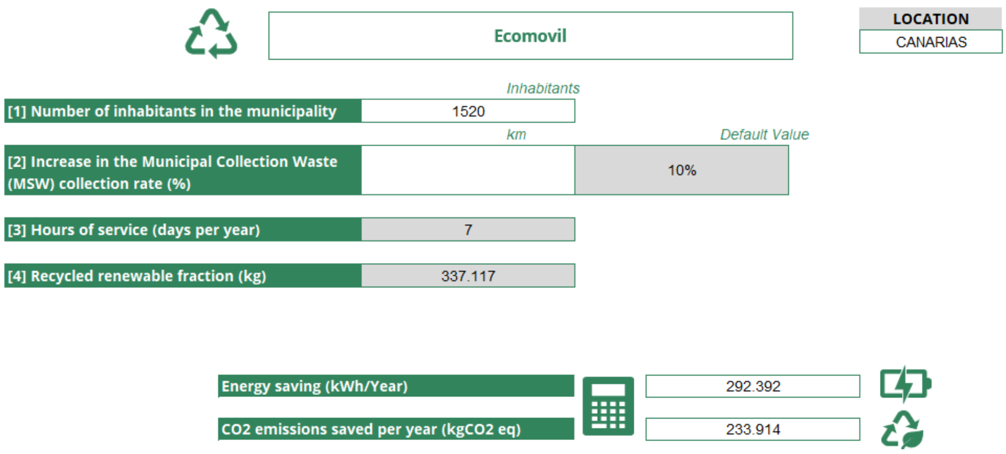


Figure 7. Visualization of the tool implementing the calculation of the municipal ecomovil action.

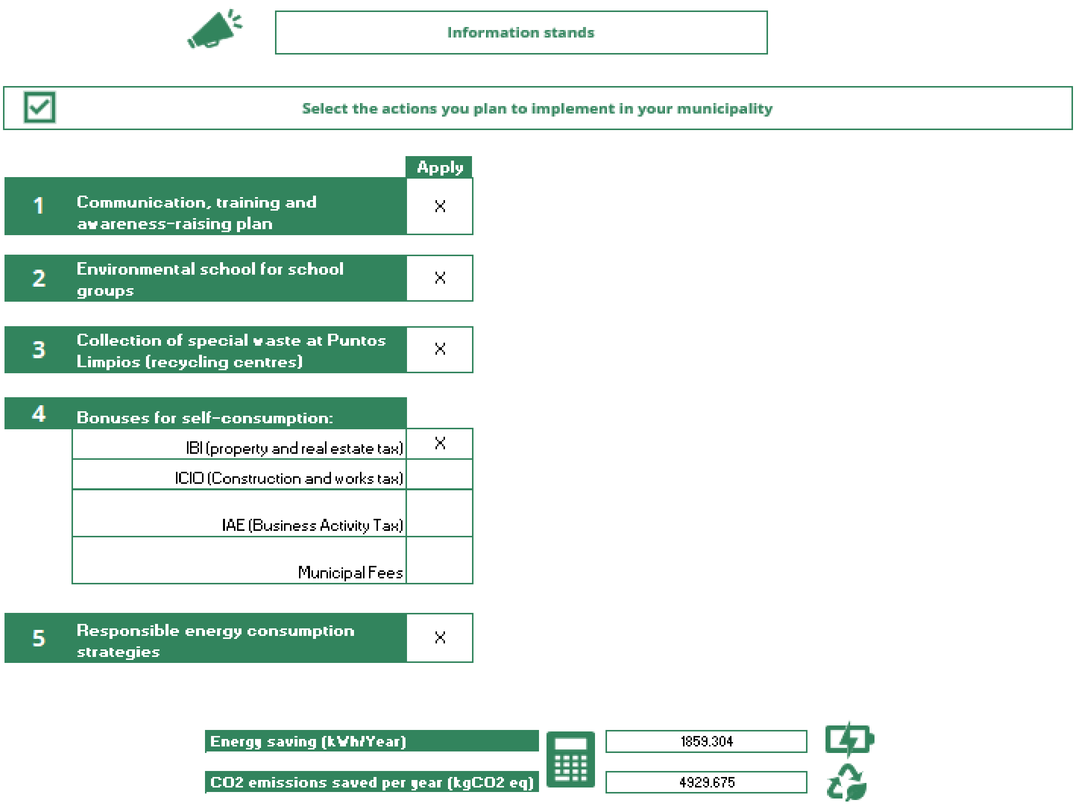
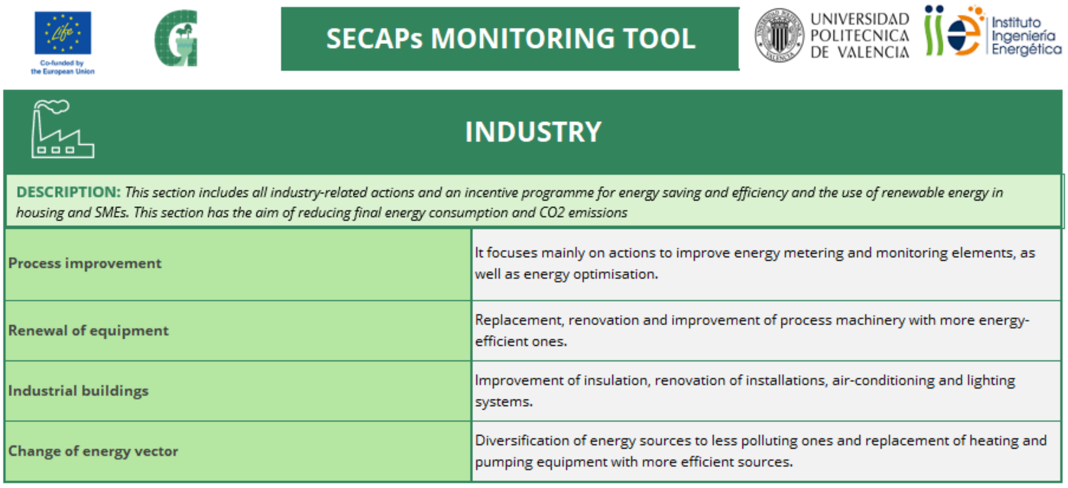


Figure 8. Visualization of the tool implementing the calculation of the information stand action

2.1.3.2. Section 2: Industry

In relation to the Industry section, different ways of promoting SMEs to achieve energy savings and efficiency are proposed, following the established in the D3.1 report, different ways and actions are proposed to encourage companies, and the corresponding energy savings that this entails.

The proposed incentive lines are maintained, being Change of energy vector, Improvement of industrial buildings, Improvement of processes and Renewal of equipment, according to the following figure:



SECAPs MONITORING TOOL

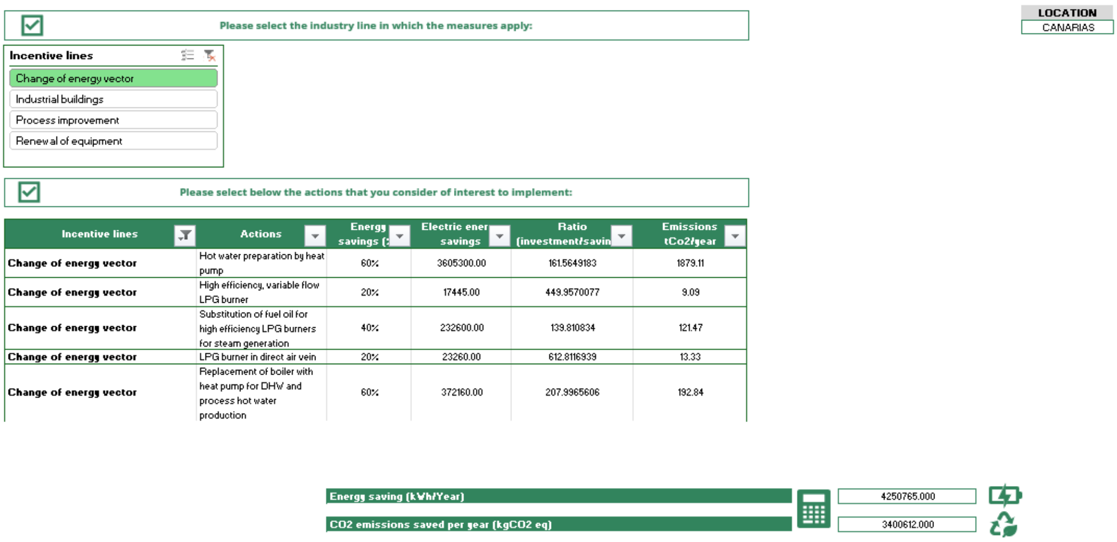
INDUSTRY

DESCRIPTION: *This section includes all industry-related actions and an incentive programme for energy saving and efficiency and the use of renewable energy in housing and SMEs. This section has the aim of reducing final energy consumption and CO2 emissions*

Process improvement	It focuses mainly on actions to improve energy metering and monitoring elements, as well as energy optimisation.
Renewal of equipment	Replacement, renovation and improvement of process machinery with more energy-efficient ones.
Industrial buildings	Improvement of insulation, renovation of installations, air-conditioning and lighting systems.
Change of energy vector	Diversification of energy sources to less polluting ones and replacement of heating and pumping equipment with more efficient sources.

Figure 9. Actions implemented in the Industry section of the toolkit

Following the technical guide for energy efficiency in industrial practice, the incentive lines to be applied for SMEs are selected and associated with energy and CO_2 savings.



Please select the industry line in which the measures apply:

LOCATION: CANARIAS

Incentive lines
- Change of energy vector
- Industrial buildings
- Process improvement
- Renewal of equipment

Please select below the actions that you consider of interest to implement:

Incentive lines	Actions	Energy savings (:	Electric ener savings	Ratio (investment/savin	Emissions tCo2/year
Change of energy vector	Hot water preparation by heat pump	60%	3605300.00	161.5649183	1879.11
Change of energy vector	High efficiency, variable flow LPG burner	20%	17445.00	449.9570077	9.09
Change of energy vector	Substitution of fuel oil for high efficiency LPG burners for steam generation	40%	232600.00	139.810834	121.47
Change of energy vector	LPG burner in direct air vein	20%	23260.00	612.8116939	13.33
Change of energy vector	Replacement of boiler with heat pump for DHW and process hot water production	60%	372160.00	207.9965606	192.84

Energy saving (kWh/Year)	4250765.000
CO2 emissions saved per year (kgCO2 eq)	3400612.000

Figure 10. Visualization of the tool implementing the calculation of the Industry actions

2.1.3.3. Section 3: Municipal Buildings and Equipment

The actions proposed in the section on Municipal Equipment and Facilities are also maintained in accordance with report D3.1, and are shown below:

SECAPs MONITORING TOOL

MUNICIPAL BUILDINGS AND PUBLIC FACILITIES

DESCRIPTION: *This section includes all actions related to municipal buildings and equipment under the responsibility of the city council.*

Improving the insulation of municipal buildings	Window improvements (replacement of glass) and façade insulation.
Improvement of municipal lighting	Replacement of luminaires with more efficient luminaires
Heating, ventilation and air-conditioning systems	Improvement of heating, cooling and DHW systems.
Introduction of renewable energies and self-consumption	Possibility of integrating renewable energies such as: solar thermal, photovoltaic and biogas, as well as introducing self-consumption at municipal level.
Municipal vehicle fleet	Current municipal vehicles: retired versus purchased with new technologies (hybrid and electric).

Figure 11. Actions implemented in the Municipal Buildings and Equipment section of the toolkit

No significant changes have been made to the proposed measures. It should simply be noted that some calculations have been simplified (such as that of the batteries) due to the need to enter a lot of data. For more specific calculations, more in-depth studies can be carried out. The following figures show the different actions in relation to municipal equipment and buildings.

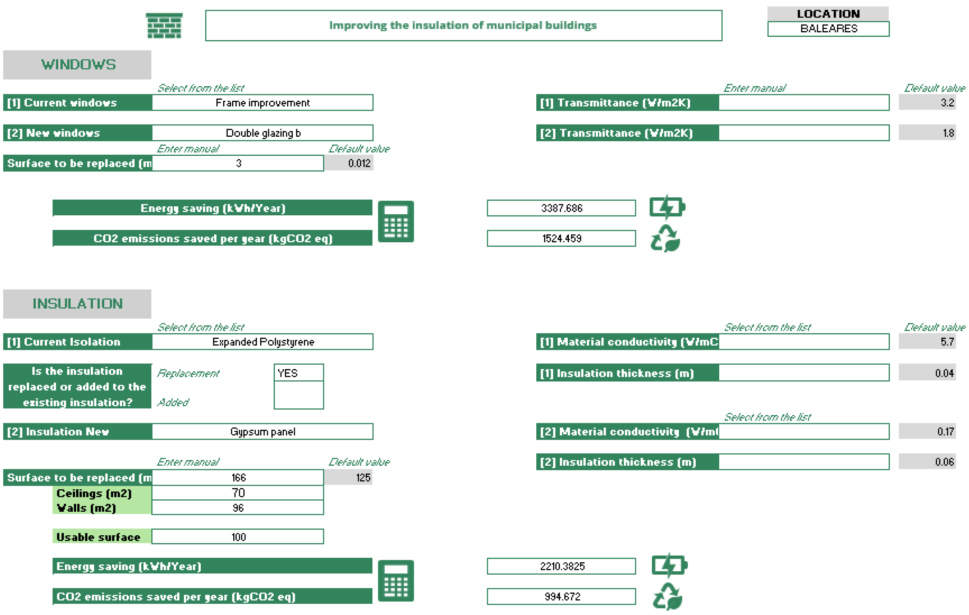


Figure 12. Visualization of the tool implementing the calculation of the improvement of insulation in municipal buildings

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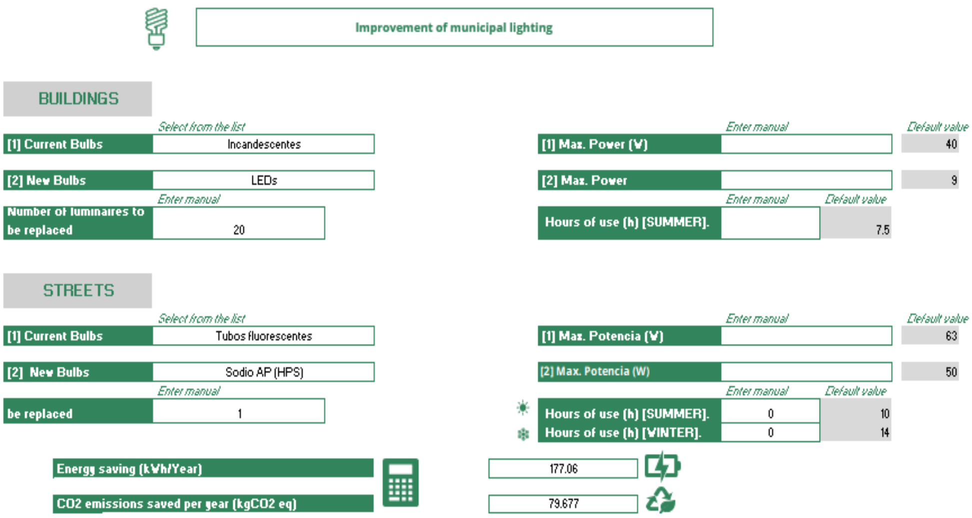


Figure 13. Visualization of the tool implementing the calculation of the improvement of municipal lighting

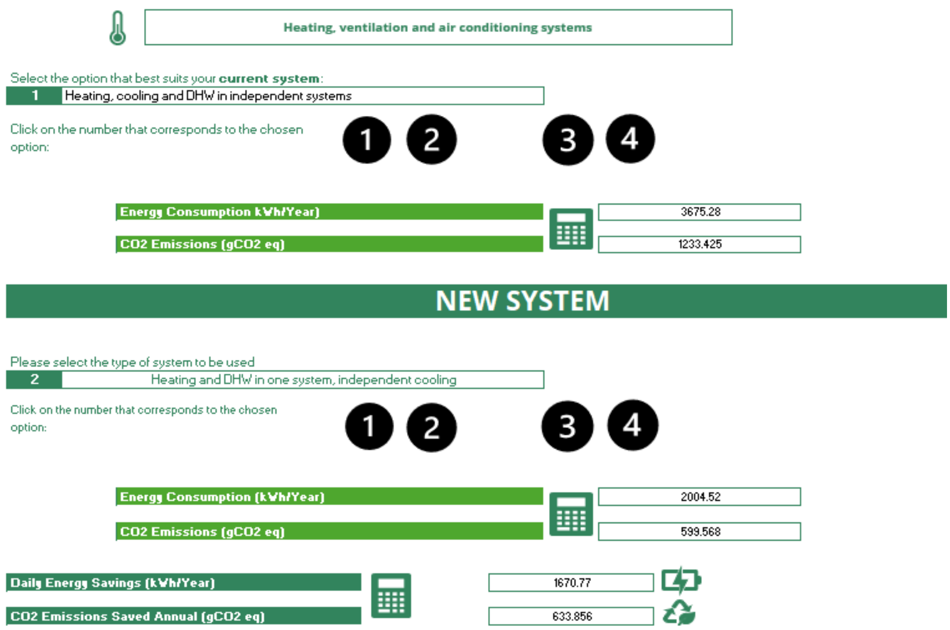


Figure 14. Visualization of the tool implementing the calculation of the improvement of heating, ventilation and air conditioning systems

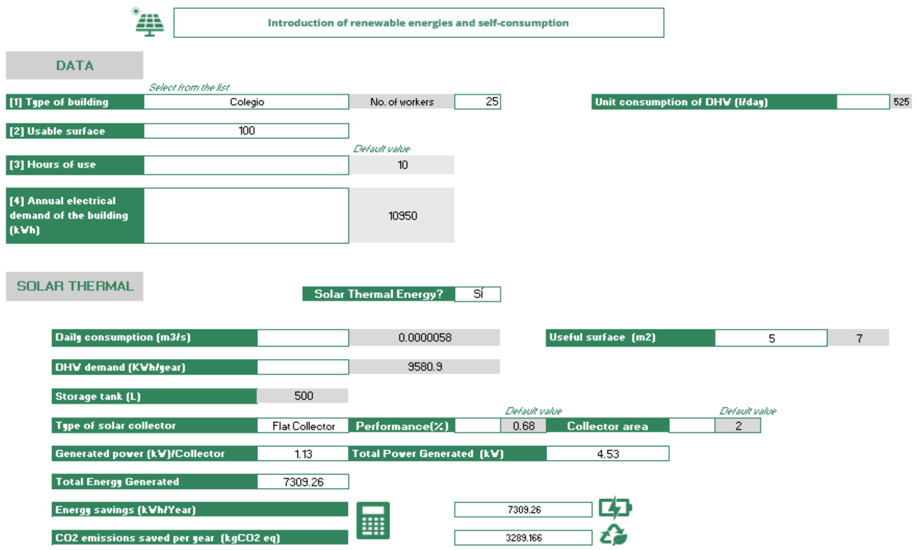


Figure 15. Visualization of the tool implementing the calculation of renewable energy: solar thermal

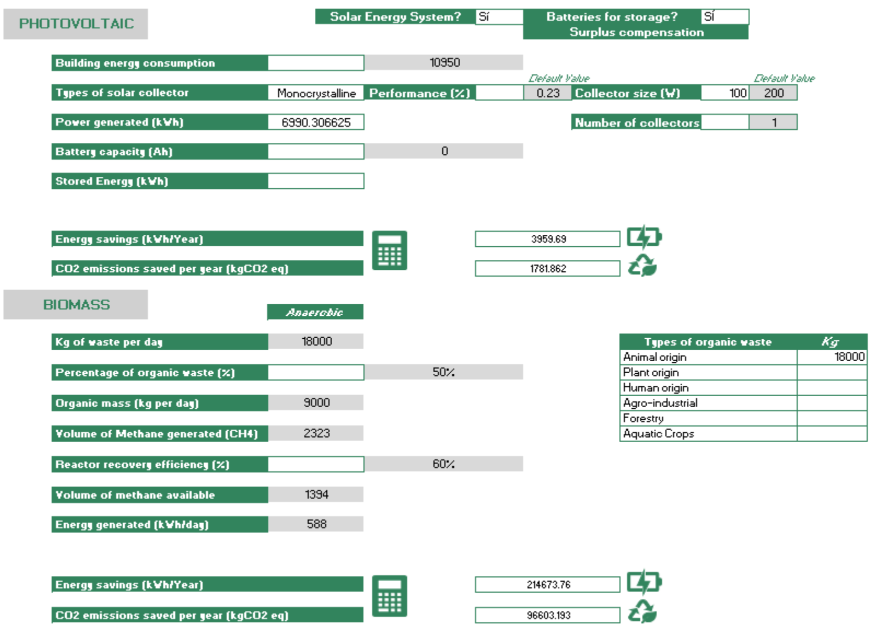


Figure 16. Visualization of the tool implementing the calculation of renewable energy: photovoltaic and biomass

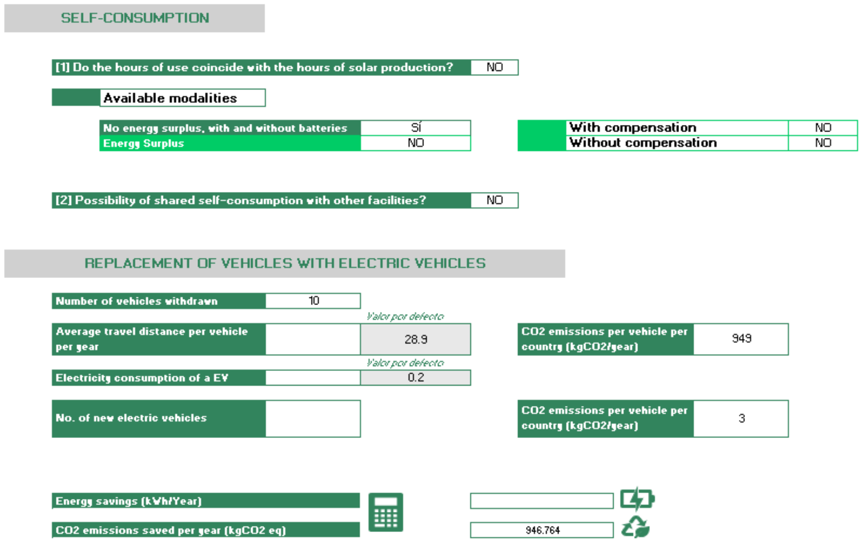
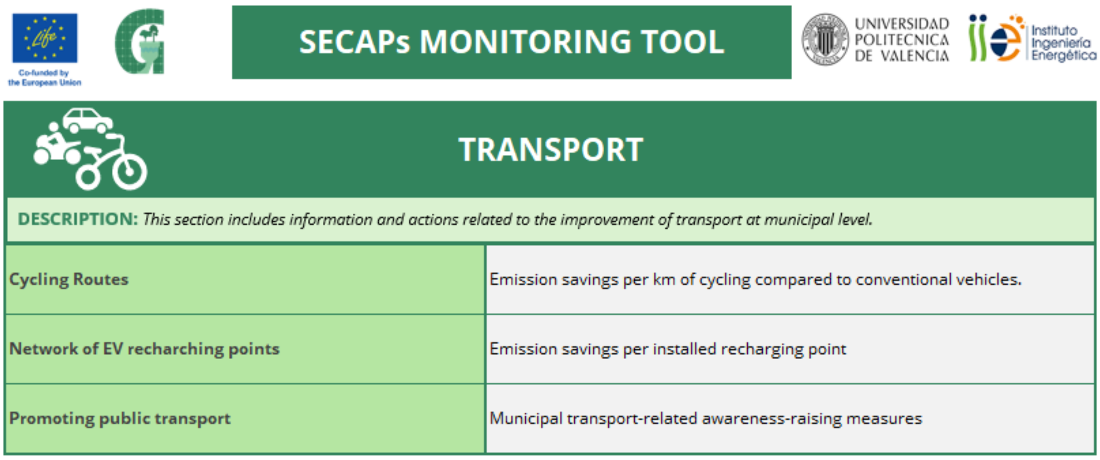


Figure 17. Visualization of the tool implementing the calculation of renewable energy: self-consumption and EV

2.1.3.4. Section 4: Transport

Finally, the actions proposed for the Transport section have also been maintained following the indications of report D3.1.



DESCRIPTION: *This section includes information and actions related to the improvement of transport at municipal level.*

Cycling Routes	Emission savings per km of cycling compared to conventional vehicles.
Network of EV recharching points	Emission savings per installed recharging point
Promoting public transport	Municipal transport-related awareness-raising measures

Figure 18. Actions implemented in the Transport section of the toolkit

The actions have been properly implemented in the tool, as shown in the following figures:

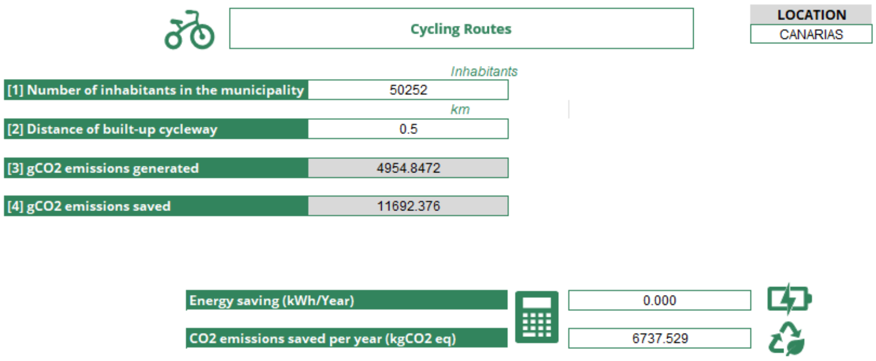


Figure 19. Visualization of the tool that implements cycleway savings in the Transport section

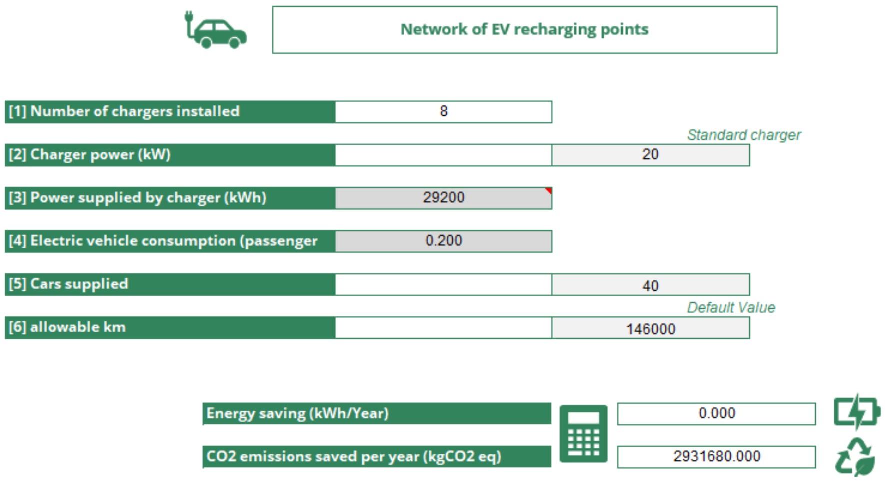
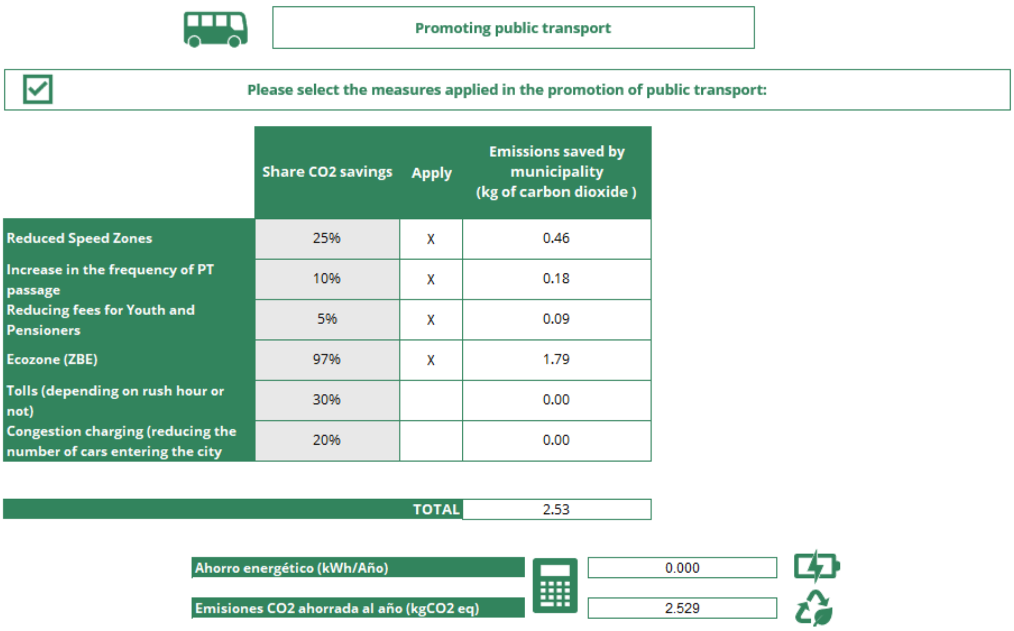


Figure 20. Visualization of the tool that implements EV recharging points savings in the Transport section



	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%	x	0.46
Increase in the frequency of PT passage	10%	x	0.18
Reducing fees for Youth and Pensioners	5%	x	0.09
Ecozone (ZBE)	97%	x	1.79
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the city	20%		0.00
TOTAL			2.53

Figure 21. Visualization of the tool that implements Public Transport measures

2.1.4. Multi-criteria Decision-Making

Multi-criteria evaluation of alternatives is considered to be the application of a method that allows the integration of quantitative and qualitative aspects of evaluation to obtain feasible solutions to be applied in SECAPs from a broader approach. Not only are the technical or economic parameters of the implementation of sustainability-related measures, such as photovoltaic solar energy in isolated communities, considered, but also the environmental, social and political variables involved in the final decision. As proposed in report D3.1, the Analytical Hierarchical Process (AHP) method has been implemented.

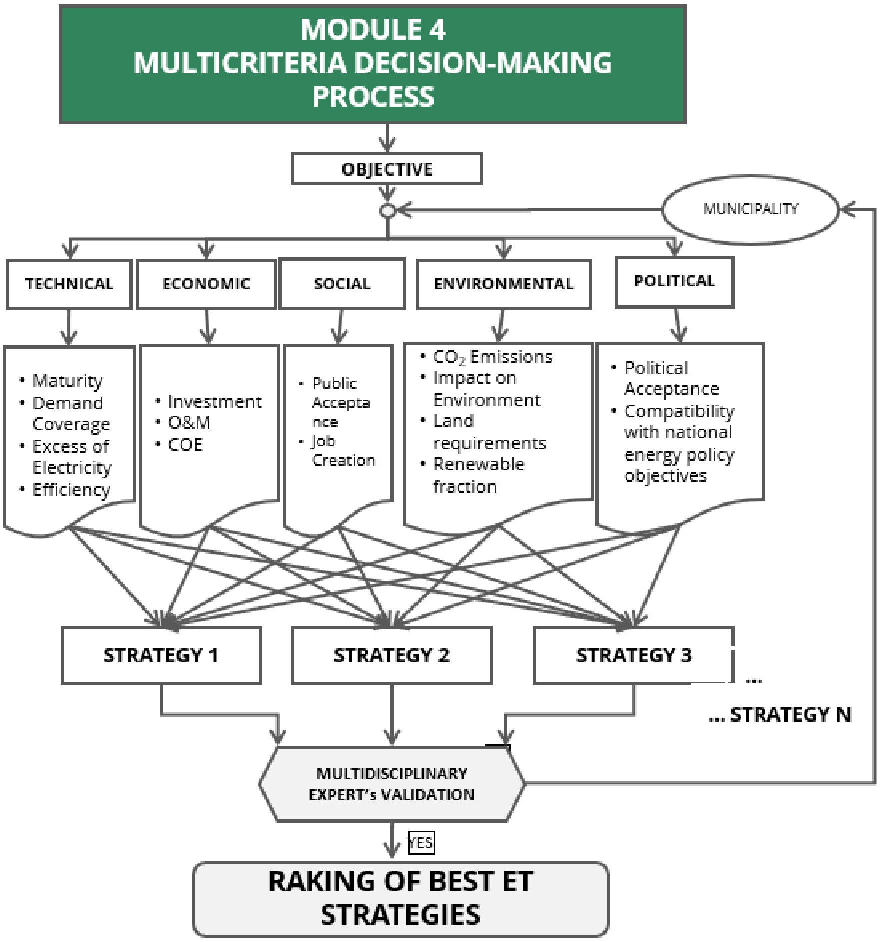


Figure 22. Outline of the AHP method with the defined criteria and sub-criteria

In order to apply the AHP method, the user is requested to enter his/her preferences, in terms of municipal interest, in a GENERA tool like the following figure:

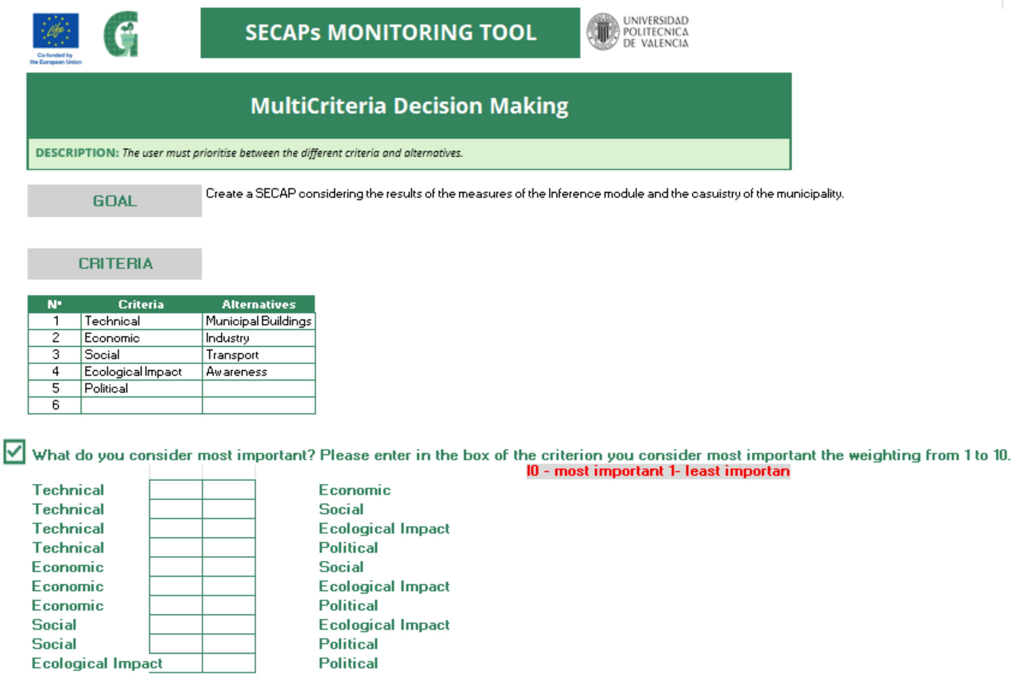


Figure 23. GENERA tool for the multi-criteria decision making method

This information is transferred to another tool where the AHP method will be applied according to the user's preferences. This is the ***Super Decisions***[1] software as a decision support method that implements the AHP. The objective would be to achieve a planning of measures according to the municipal casuistry.

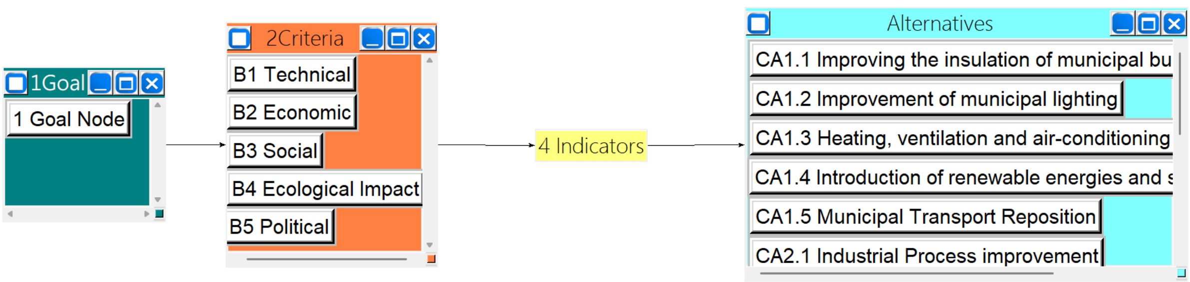


Figure 24. Visualization of the Super Decisions Software to implement the AHP method

The indicators that have been chosen to evaluate the different alternatives are shown in the following table. In addition, it is also indicated to which criteria (second level) each one of them applies.

Indicator	Criteria to which it applies
Maturity	Technical
Municipal RE Share (%)	Technical, Ecological impact

[1] https://www.superdecisions.com/

Indicator	Criteria to which it applies
Annual Energy Savings (MWh)	Technical, Economic, Ecological impact
Annual RE Production (MWh)	Technical
Implementation Rate	Technical
Investment	Economic
Annual Profitability (kWh/€)	Economic
Available Funding and Grants	Economic
Public Acceptance	Social, Political
Job Creation	Economic, Social, Political
CO_2 Emissions Reduction (tCO_2)	Ecological impact, Political
Biodiversity Impact	Ecological impact
Land Change of Use	Social, Ecological impact, Political
Political Acceptance	Political
Compatibility with national Policies	Political
Compatibility with regional Policies	Political
Compatibility with EU Policies	Political

Table 1. Indicators included in the AHP method

Thus, each of the actions included in the municipal AP will be evaluated according to the established criteria and indicators. Each policy maker should evaluate according to their policy which criteria have more weight in their method of governance, and the value of each of the measures in relation to the established indicators.

Each indicator will first be compared with respect to the criteria given, as shown in the following figure:

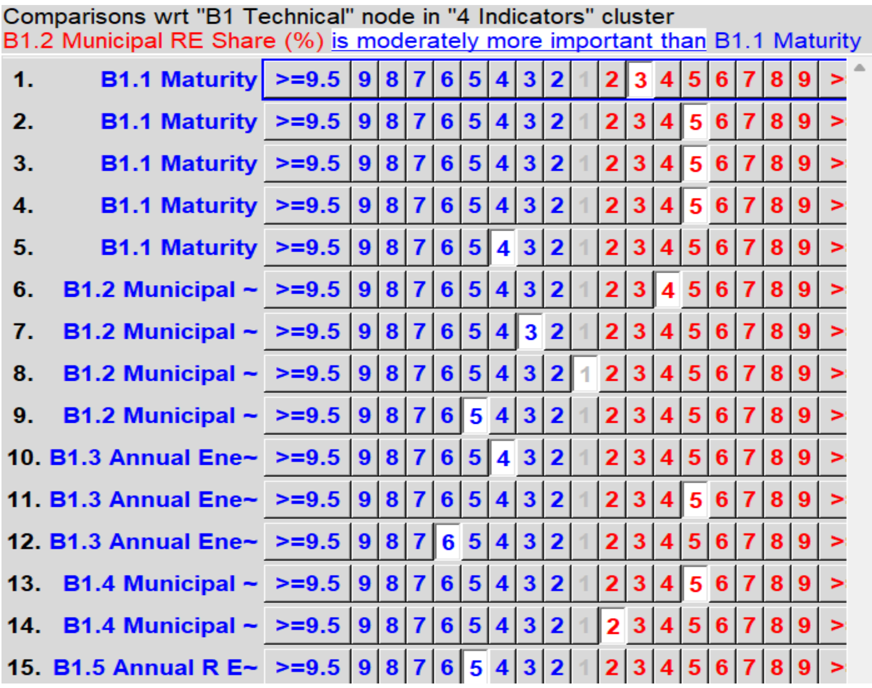


Figure 25. Comparison of indicators according to the given criteria. Screenshot of the *Super Decisions* software

The same procedure will then be carried out with an alternative face for each indicator. Finally, a report will be obtained evaluating each alternative with the municipal criteria and will result in a ranking of measures specific to that municipality.

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0101	0.0303	0.0763	8
	CA1.2 Improvement of municipal lighting	0.0160	0.0484	0.1218	7
	CA1.3 Heating, ventilation and air-conditioning systems	0.0316	0.0953	0.2400	4
	CA1.4 Introduction of renewable energies and self-consumption	0.1317	0.3969	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0060	0.0181	0.0456	9
	CA2.1 Industrial Process improvement	0.0029	0.0087	0.0219	13
	CA2.2 Renewal of industrial equipment	0.0027	0.0081	0.0204	14
	CA2.3 Improvement of Industrial buildings	0.0059	0.0178	0.0449	10
	CA2.4 Change of energy vector	0.0049	0.0149	0.0375	11
	CA3.1 Cycling Routes	0.0320	0.0966	0.2433	3
	CA3.2 Network of EV recharging points	0.0185	0.0559	0.1408	6
	CA3.3 Promoting public transport	0.0226	0.0682	0.1718	5
	CA4.1 Ecomovil	0.0045	0.0135	0.0341	12
	CA4.2 Information stands	0.0422	0.1273	0.3208	2

Figure 26. Final evaluation of alternatives. Screenshot of the *Super Decisions* software.

3. Pilots Results

In this section the ET tools are validated in 6 municipalities of GENERA's tourist islands: **2** in Spain, **1** in Italy and **3** in Greece. This is done as a pilot to get feedback on the use of the tools, and to be able to improve them in the future according to the comments. As mentioned above, first a national analysis is carried out, and then the focus will be on the municipalities of interest.

In order to understand the different regions, a first analysis was carried out in Deliverable "*D4.1 Road-mapping needs, typology, Island-specific recipes*". It consisted of a first characterization of the island regions located in Spain (Balearic and Canary Islands), France (Corsica), Italy (Sicily and Sardinia) and Greece (North Aegean and South Aegean).

This section is then divided according to the different countries in which the pilot municipalities are located: Spain, Italy and Greece. For each country, the study of the national energy context will be carried out using the corresponding tool, and then the specific modules for each municipality will be used.

3.1. Spain

Spain is a country that has a uniform overall production with several energy sources, with the greatest variation in the use of natural gas and the expected variation in solar energy production. Spain in particular is characterized mainly by low per capita electricity consumption, as well as lower mineral depletion. Consequently, based on these low levels of per capita electricity consumption, one of the clear objectives for these countries is to continue modifying the electricity matrix towards greater generation from renewable sources. Spain, Italy and Spain have very similar electricity generation from renewable sources, around 45% of total electricity [1].

In relation to the Spanish islands and archipelagos of the Balearic and Canary Islands, they are said to have a high population density, but are also characterized by a fair employment rate, and are highly dependent on tourism, especially the Balearic Islands.

3.1.1. Study of the Spanish National Context

At the national level, this section studies the energy context in Spain. The reference data are taken from the year 2023, which is the year for which complete information is available. In general terms, the Spanish energy mix in relation to energy supply is mainly divided into oil (42.9%), followed by natural gas (22.5%), nuclear energy (13.2%) and continued by geothermal, solar and wind energy, biofuels and waste and hydroelectric energy. CO_2 emissions in Spain have been reduced by 22% with respect to 2000 data, and this places Spain as the producer of 0.64% of global emissions.

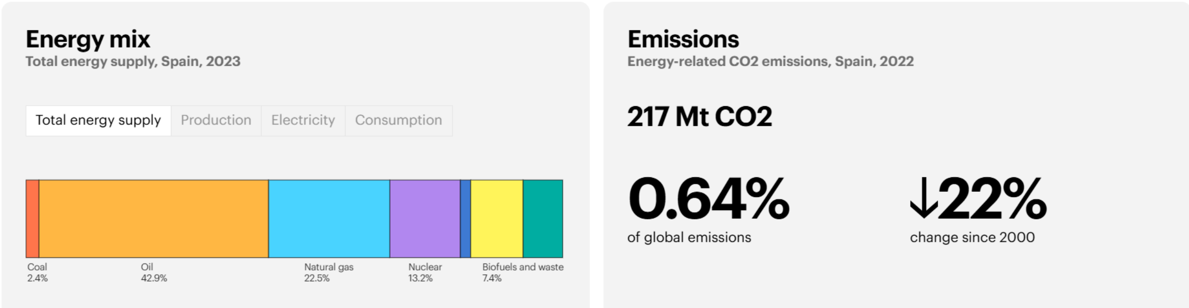


Figure 27. Summary of Spain's energy mix and emissions. Source: https://www.iea.org/countries/spain

In this case, Module 1 of the GENERA tools is used, which calculates the energy context of the selected country. The data entered in the tool take 2022 as the reference year (since 2023 is incomplete for some sectors) and comes from the International Energy Agency [1].

First, an overview of the contribution of each energy source in the main sectors of the Spanish economy is obtained: transport, industry, residential, services and others (agriculture, fishing, etc.). In addition, the contribution to electricity generation is also shown.

Oil is the main source in the transportation sector and in other sectors such as agriculture, fishing, etc. On the other hand, natural gas is more involved in the industry, residential and service sectors. In addition, in electricity production, natural gas and renewables are the main producers.

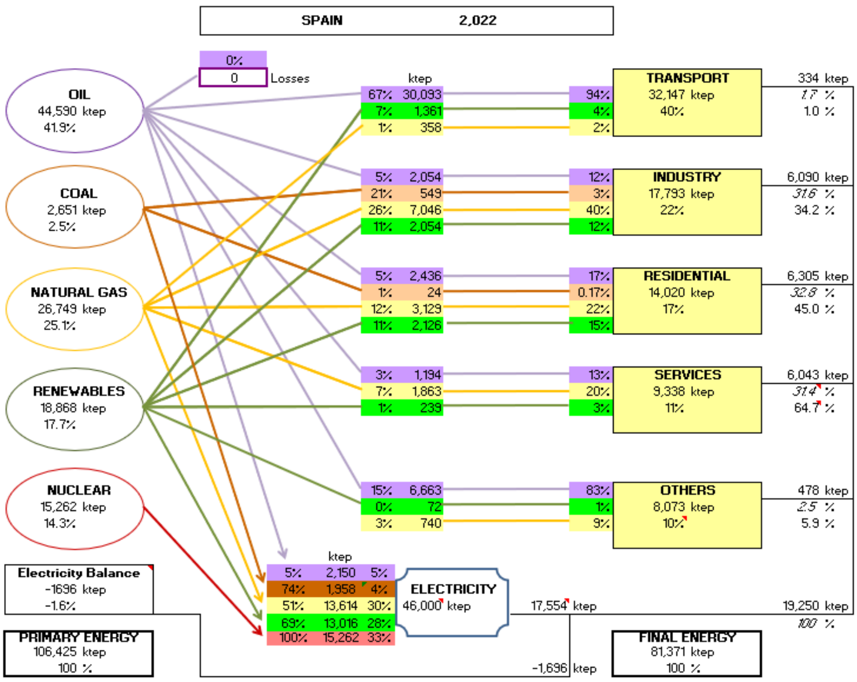


Figure 28. Energy balance of the different energy sources and sectors in Spain

Subsequently, the tool calculates the progression of different indicators, such as primary energy demand, electricity generation and emissions up to 2030, following current trends.

Figure *29* shows the evolution of primary energy demand in the current Spanish system. According to the data shown in Figure *28*, the greatest demand is for oil and, although it is possible that policies to reduce the use of oil will be implemented, according to the current situation it will continue to grow progressively. Likewise, the trend of renewable energies is also growing and, with the application of measures to promote their use, they could even equal the use of natural gas. Finally, nuclear energy and coal remain constant, with coal being the least demanded energy.

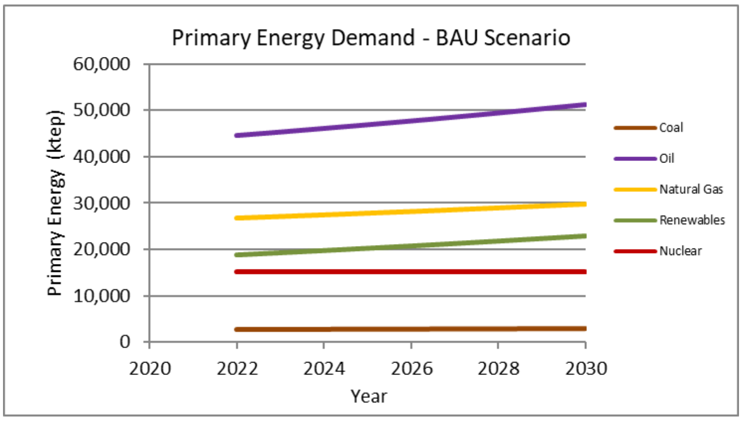


Figure 29. BAU Spain Scenario: Primary Energy Demand

In relation to the contribution of each source to electricity generation, nuclear energy in Spain stands out for its production and stability, which is characteristic of this energy source. Also noteworthy is the growing generation by renewable energies, which will continue to grow and, if measures are implemented, could even increase. In addition, the growing use of natural gas also stands out. The latter could decrease in the future due to the recent conflict with Russia, as the demand for gas in Europe has decreased. Finally, oil and coal maintain a similar and stable value and are the last sources in terms of contribution to electricity generation.

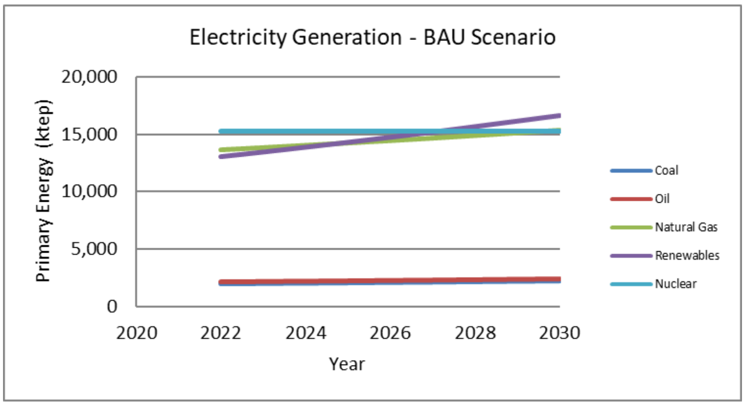


Figure 30. BAU Spain Scenario: Electricity Generation

A further outcome of this tool is the contribution of each sector, for example, in terms of CO_2 emissions generation. In Spain, the main CO_2 generating sector is transportation, so implementing measures to reduce it is of paramount importance. This is followed by the electricity sector, which could be reduced by encouraging the use of renewable energy or less CO_2-producing sources such as natural gas. Minor emissions are found in the agriculture and fishing, industrial, residential and services sectors.

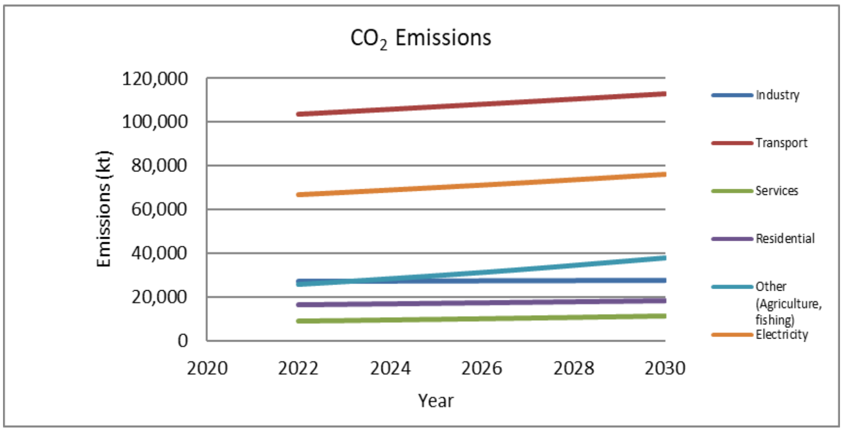


Figure 31. BAU Spain Scenario: CO_2 Emissions

In summary, Spain's energy context is characterized by the use of oil mainly for the transport sector, which in turn generates most of the country's emissions. On the other hand, there is a growing trend towards the use of renewable energy, mainly for electricity production, but also for residential use. Natural gas also shows a growing trend and greater involvement in the industrial, residential and service sectors. The use of nuclear energy provides a stable energy base that, for now, is maintained over the years. Finally, the use of coal is very low. In terms of emissions, the most damaging sector is transport, followed by electricity generation. All this should be considered when creating action plans, as more sustainable future scenarios can be achieved by implementing policies to reduce emissions and support renewable energies

3.1.2. Pilot 1 in Ibiza (Balearic Islands): Sant Antoni

3.1.2.1. Features of Sant Antoni de Portmany

Sant Antoni de Portmany is located in the northwest of the island of Ibiza. The municipality has an area of 12,662 hectares and a population of 27,431 inhabitants [2]. In 2021 the city council of Sant Antoni de Portmany signed the new Covenant of Mayors for Climate and Sustainable Energy, which implied that all the commitments established in the 'document of official commitments' would be assumed in this plenary document.

The climate in Sant Antoni de Portmany is a local steppe. It is characterized by little rainfall during the year. The average temperature in Sant Antoni de Portmany is 18,5 °C. The consequences of climate change are multiple and the impact on the water cycle has important effects on the development of an area's activities. The influence of human activity in this aspect is the cause of current water-related risks and vulnerabilities, from long periods of drought to the presence of a significant risk of flooding. The municipality of Sant Antoni de Portmany, after the signing of the Covenant must consider "the adaptation of the structures including the allocation of appropriate human and economic resources" as a formal commitment. The creation and implementation of sustainable energy policies is a process that requires a lot of time and effort and has to be systematically regulated and supervised between the different areas of administration: environment, planning, intervention, social affairs, municipal services, mobility, economic area, participation etc.

Among the main objectives set at the municipal level are:

Section	Objective
Renewable energy	It has set the promotion of renewable energies so that they represent at least **32% of the energy consumption** of the municipality in the year 2030, in order to make its commitment to the Covenant of Mayors for Energy and Climate a reality.
Energy efficiency	**Increase the city's energy efficiency by 32.5%** by the year 2030, with respect to 2005 energy consumption, in order to fulfil its commitment
CO_2 emissions	The global emissions reduction target for the year 2030 in the municipality of Sant Antoni de Portmany of 55% of 2005 emissions represents a reduction of 63,838.23 tons of CO_2.

Table 2. Municipal objectives of Sant Antoni de Portmany

3.1.2.2. Summary of actions of Sant Antoni de Portmany

After a detailed study of the actions included in Sant Antoni De Portmany at municipal level and, specifically, in the Covenant of Mayors for Climate and Energy, for the creation and updating of the Action Plan [3], the measures are introduced in the GENERA tool for the evaluation of alternatives. The actions have been considered according to the different sections detailed in the inference module.

Municipal Buildings And Public Facilities

- **Indoor lighting renovation**

The city council will commit to a policy of purchasing more energy-efficient lighting fixtures. It includes 13 buildings and a cost per building of €8,000. It is considered that 12% of the usable area of public buildings should be destined to natural ventilation and lighting. This implies that in Sant Antoni de Portmany, considering 13 buildings in which to intervene (5 schools, town hall, municipal swimming pool, sports pavilion, bus station and other large buildings), with an average of 600 square meters of usable area, it is intended to refurbish 936 square meters.

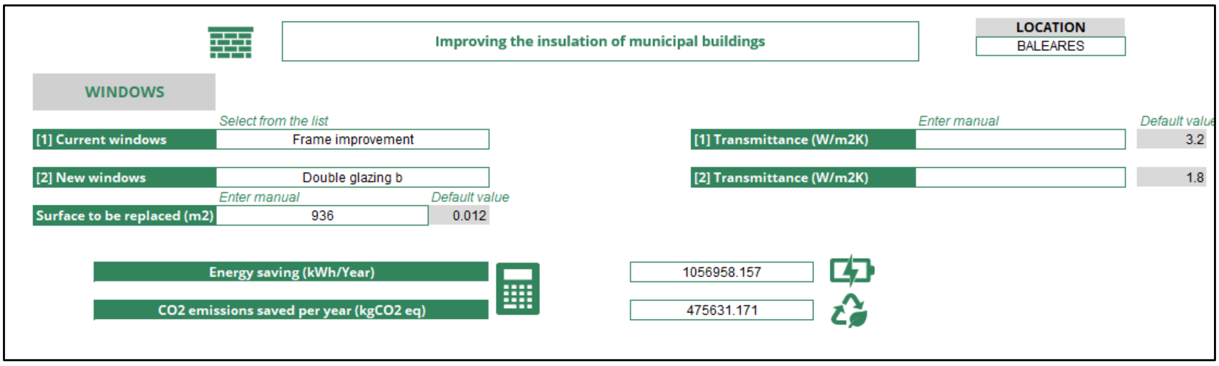


Figure 32. Improvement of the windows of Sant Antoni de Portmany

- **Substitution Of Lights For More Efficient Ones**

On the other hand, another action is the replacement of lighting fixtures in buildings and streets with more efficient ones, such as LEDs.

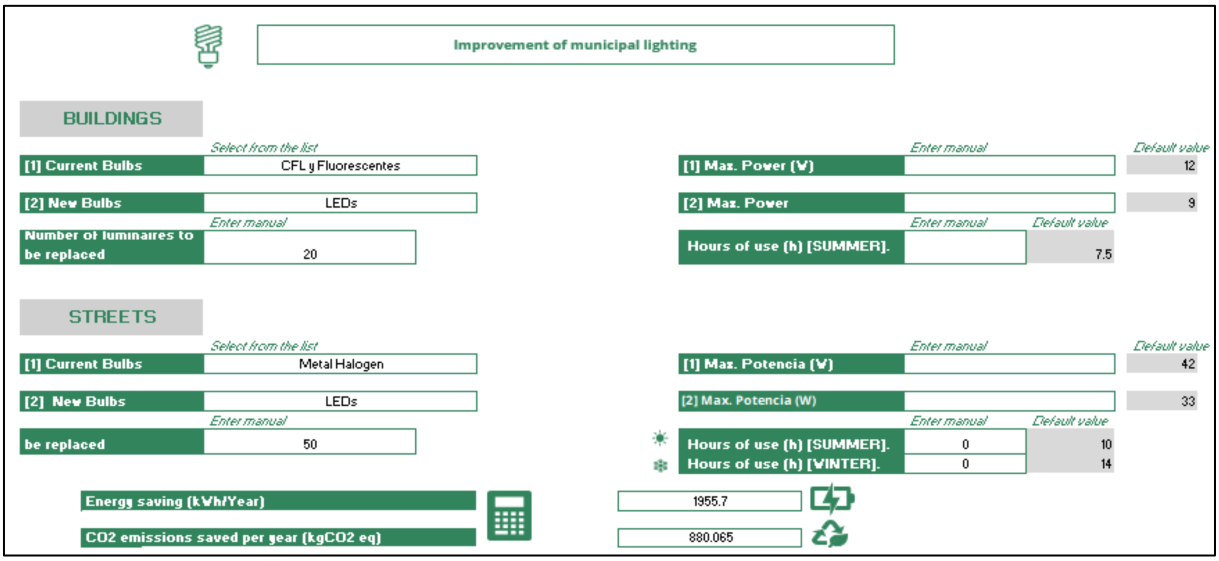


Figure 33. Change of lighting fixtures in public buildings and streets in Sant Antoni de Portmany

- **Installation of aerothermal energy in municipal facilities**

In this case, a change is made in the air conditioning system of several public buildings. These have a standard oil boiler for heating and domestic hot water, whose energy consumption is as follows:

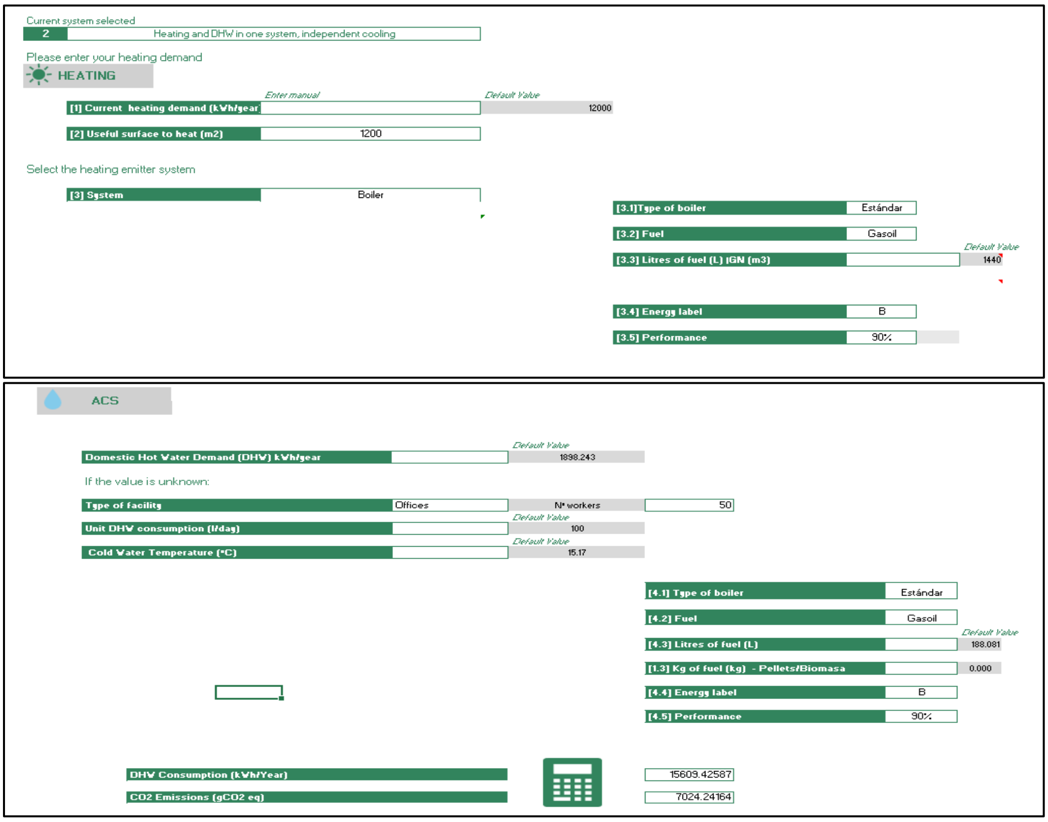


Figure 34. Calculation of the previous heating and DHW system in Sant Antoni de Portmany

The cooling system uses air conditioning fan coils, as shown in the figure below, with their respective energy consumption and emissions:

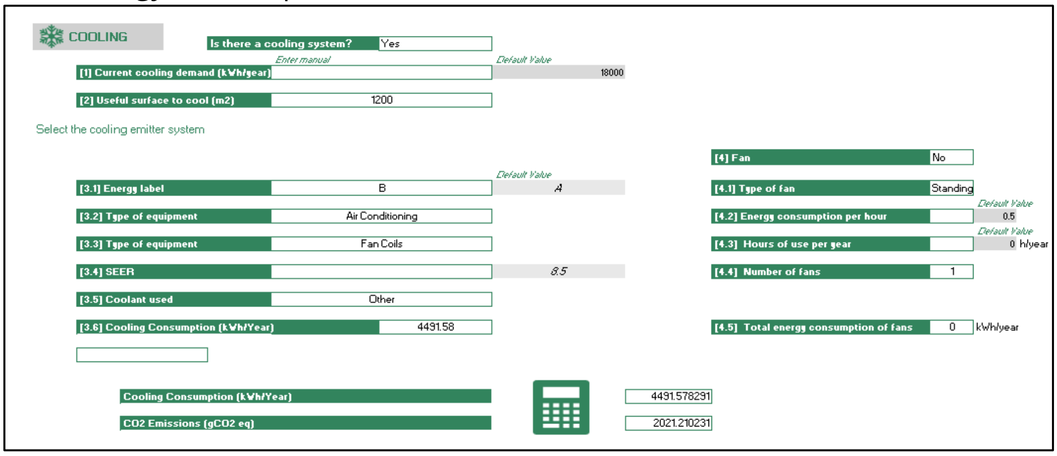


Figure 35. Calculation of the pre-cooling system in Sant Antoni de Portmany

The new system proposed is the use of an aerothermal system, both for heating and cooling and for domestic hot water. The energy consumption and emissions can be seen in the following figure

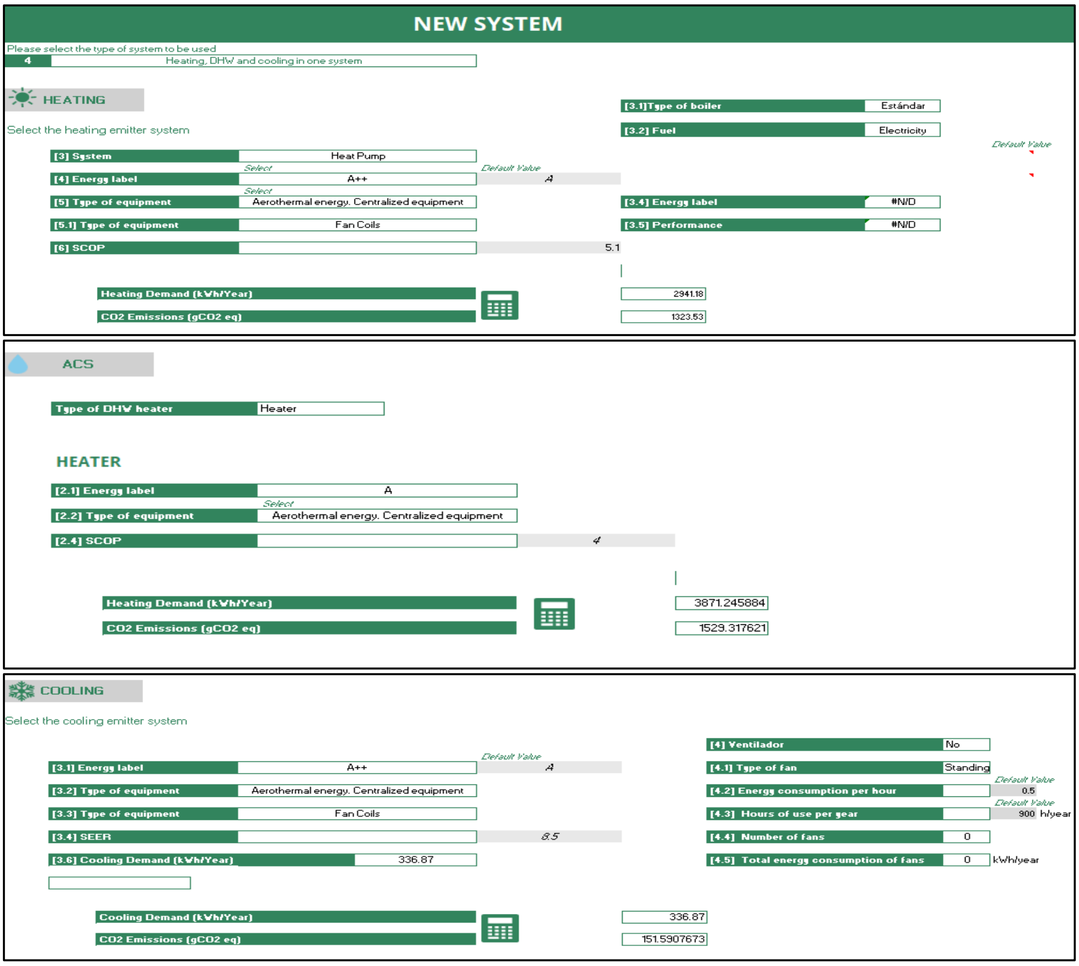


Figure 36. Calculation of the new air-conditioning system for public buildings in Sant Antoni de Portmany

In summary, the savings in terms of annual energy and CO_2 emissions are as follows:

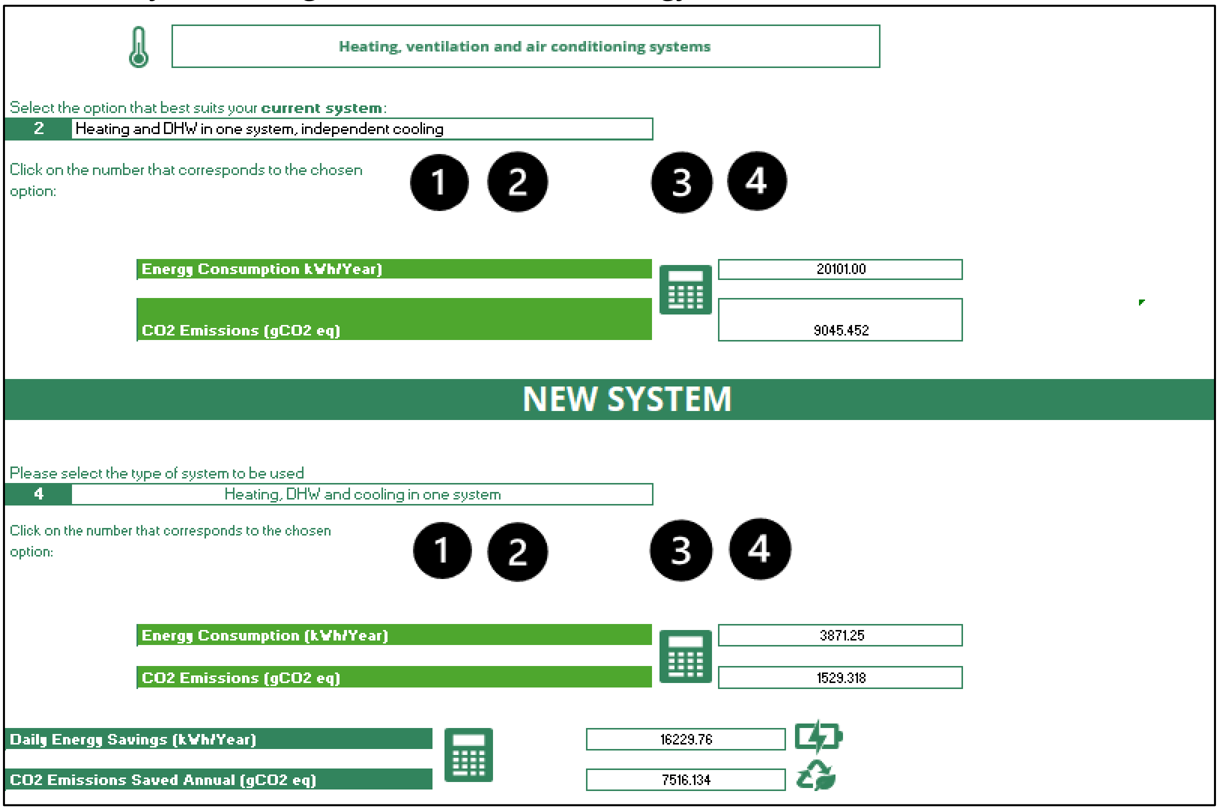


Figure 37. Energy savings and CO_2 emissions in the air conditioning of Sant Antoni de Portmany

- **Photovoltaic solar energy installations**

One of the other actions to be implemented was the introduction of renewable energy in public buildings. In this case, the option of photovoltaic solar energy was proposed, and monocrystalline panels were proposed. As the current energy consumption is not available, the estimate given by the tool is used. In addition, the use of batteries is not considered initially.

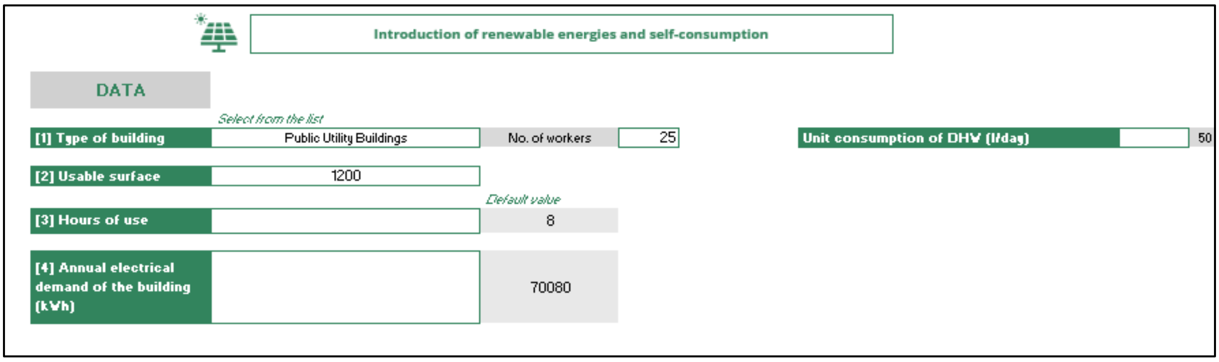


Figure 38. Necessary data for the introduction of renewable energy in Sant Antoni de Portmany

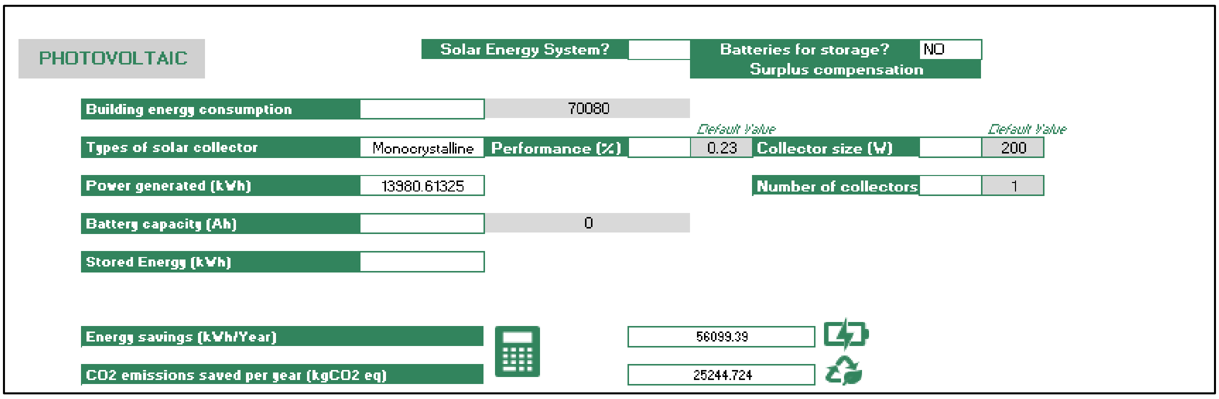


Figure 39. Use of renewable energy, solar panels, in Sant Antoni de Portmany

- **Replacement of municipal vehicles with more efficient ones**

It is proposed that the fleet of municipal vehicles be progressively replaced by low-emission and more efficient vehicles at the end of their useful life, such as electric vehicles or vehicles that use renewable sources. The acquisition of these vehicles by the municipality promotes their purchase by the population, especially if this good practice is properly disseminated. The number of vehicles to be replaced is 20.

GENERA's tool calculates the CO_2 emissions avoided with the new vehicles. If the emissions value for each vehicle is not known, the tool provides default values.

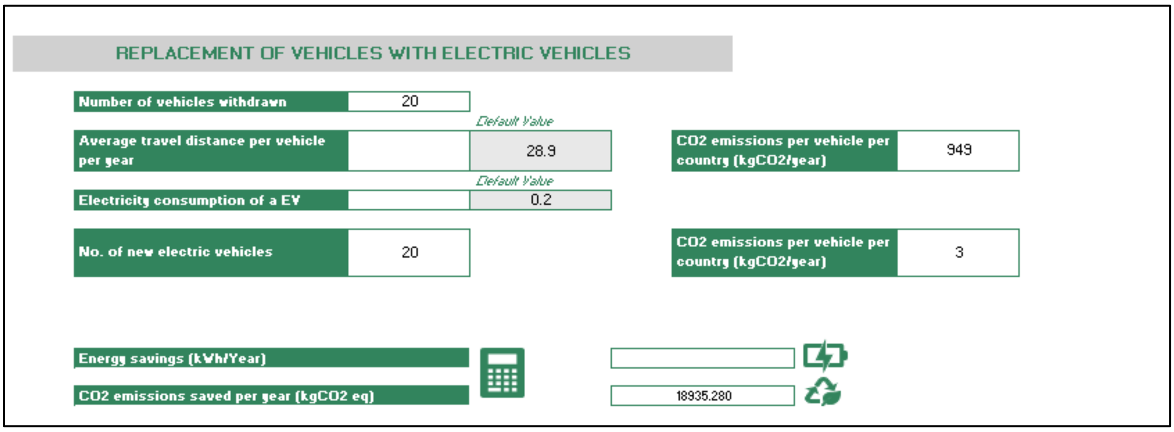


Figure 40. Replacement of conventional vehicles by electric vehicles in Sant Antoni de Portmany

Industry

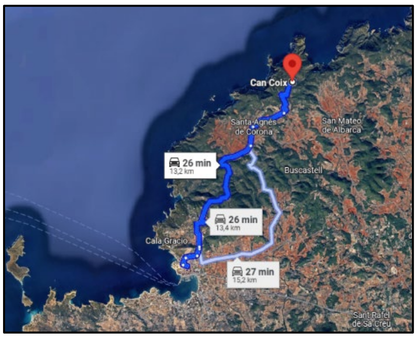
In this case, the municipality of Sant Antoni is committed to measures aimed at the residential and service sector, more related to public awareness and sensitization.

Transport

- **Increase of cycling routes**

This measure focuses on increasing the bicycle lane available in the municipality, it is an improvement for cyclists because they can ride through the city without risking their lives or hindering traffic. This action includes the creation of a bicycle lane from Sant Antoni to

Ca Coix by the Consell Insular. The shortest distance is 13.2 km, so the estimated bike lane length is 20 km.



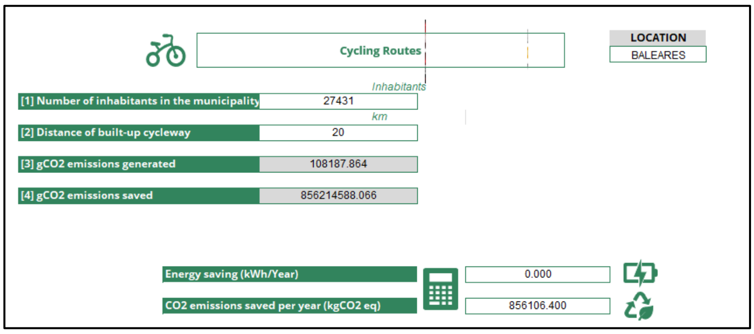


Figure 41. Calculation of the cycling route for Sant Antoni de Portmany. Source: https://www.google.es/maps/?hl=es

- **Network of EV recharging points**

Another transport-related measure is the inclusion of electric vehicle charging points. In this case, the municipality of Sant Antoni plans to introduce 13 recharging points, and has already installed 5. Therefore, there is the possibility of introducing 8 more, and consequently, it translates into the reduction of emissions that means that citizens can use EVs instead of conventional ones.

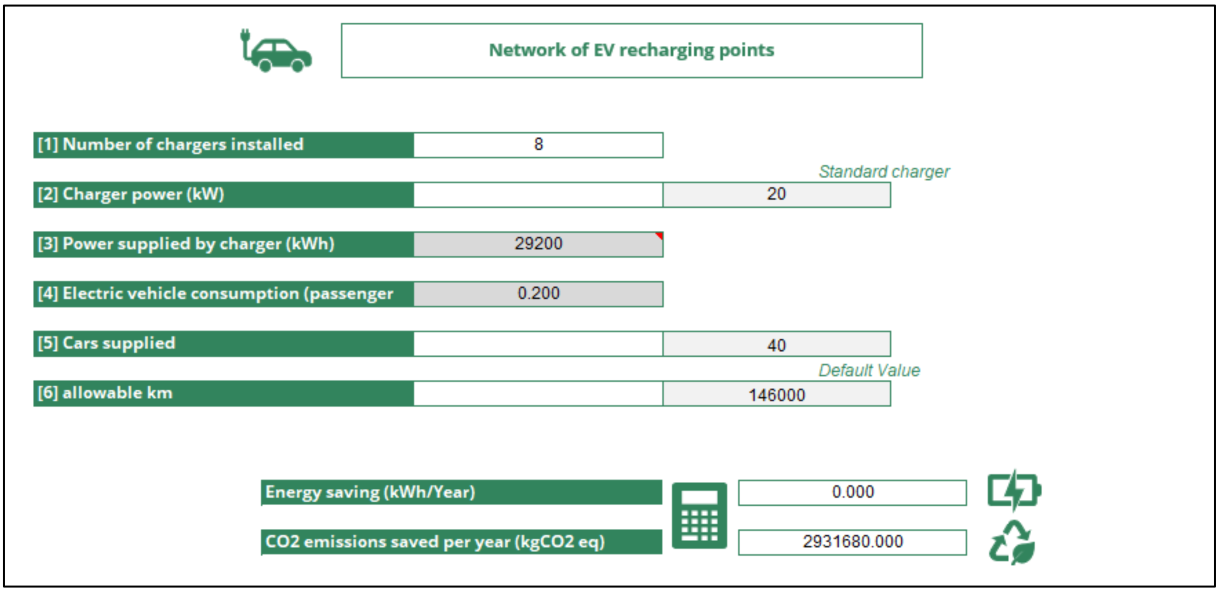


Figure 42. Introduction of EV recharging points in Sant Antoni de Portmany

- **Measures to promote public transport and reduce private vehicle use**

Finally, measures to promote public transport are proposed. To this end, some measures include the introduction of low emission and reduced speed zones, as well as the introduction of bonuses for young people and senior citizens, and an increase in the frequency of public transport.

Promoting public transport

Please select the measures applied in the promotion of public transport:

	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%	x	0.25
Increase in the frequency of PT passage	10%	x	0.10
Reducing fees for Youth and Pensioners	5%	x	0.05
Ecozone (ZBE)	97%	x	0.98
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the city	20%		0.00
TOTAL			1.38

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	37864.726

Figure 43. Promotion of public transport in Sant Antoni de Portmany

Awareness

- **Awareness-raising information stands**

Lastly, to raise public awareness, awareness-raising measures are proposed, such as:

- Awareness campaigns for young people in schools
- Tax rebates on building permits for renewables.
- Recycling campaigns and workshops
- Creation of a communication and awareness plan for energy savings

Select the actions you plan to implement in your municipality

		Apply
1	Communication, training and awareness-raising plan	x
2	Environmental school for school groups	x
3	Collection of special waste at Puntos Limpios (recycling centres)	x
4	Bonuses for self-consumption:	
	IBI (property and real estate tax)	
	ICIO (Construction and works tax)	X
	IAE (Business Activity Tax)	
	Municipal Fees	
5	Responsible energy consumption strategies	x

Energy saving (kWh/Year)	33554.323
CO2 emissions saved per year (kgCO2 eq)	77220.413

Figure 44. Awareness-raising information stands in Sant Antoni de Portmany

3.1.2.3. Multicriteria Decision in Sant Antoni

Once the relevant calculations have been made in relation to the actions implemented in the municipality, the last tool is the decision-making module that allows the evaluation of the different actions according to the municipal casuistry.

Using the *Super Decisions* software, priorities are entered at each level, prioritizing among the criteria: technical, economic, social, ecological and political impact. Another prioritization will then be made among the different indicators that will result in the order of priority of the proposed actions at the municipal level.

Considering the priorities established by the municipality, the criteria used to prioritize the different levels are as follows:

- Raise awareness and educate citizens about climate change.
- Promote energy efficiency and the use of renewable sources.
- Encourage responsible resource management
- Design a sustainable and efficient municipality

Taking all this into account, the valuations are introduced in the chosen software applying the AHP method and a final report suitable for the municipality of Sant Antoni de Portmany is obtained.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0181	0.0549	0.2733	8
	CA1.2 Improvement of municipal lighting	0.0101	0.0306	0.1522	11
	CA1.3 Heating, ventilation and air-conditioning systems	0.0664	0.2008	1.0000	1
	CA1.4 Introduction of renewable energies and self-consumption	0.0605	0.1831	0.9118	2
	CA1.5 Municipal Transport Reposition	0.0197	0.0596	0.2967	7
	CA2.1 Industrial Process improvement	0.0031	0.0094	0.0469	13
	CA2.2 Renewal of industrial equipment	0.0034	0.0104	0.0517	12
	CA2.3 Improvement of Industrial buildings	0.0031	0.0093	0.0461	14
	CA2.4 Change of energy vector	0.0110	0.0333	0.1656	10
	CA3.1 Cycling Routes	0.0373	0.1130	0.5626	3
	CA3.2 Network of EV recharging points	0.0277	0.0837	0.4169	5
	CA3.3 Promoting public transport	0.0272	0.0823	0.4100	6
	CA4.1 Ecomovil	0.0130	0.0394	0.1962	9
	CA4.2 Information stands	0.0298	0.0902	0.4490	4

Figure 45. Report on alternatives obtained for the municipality of Sant Antoni de Portmany

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

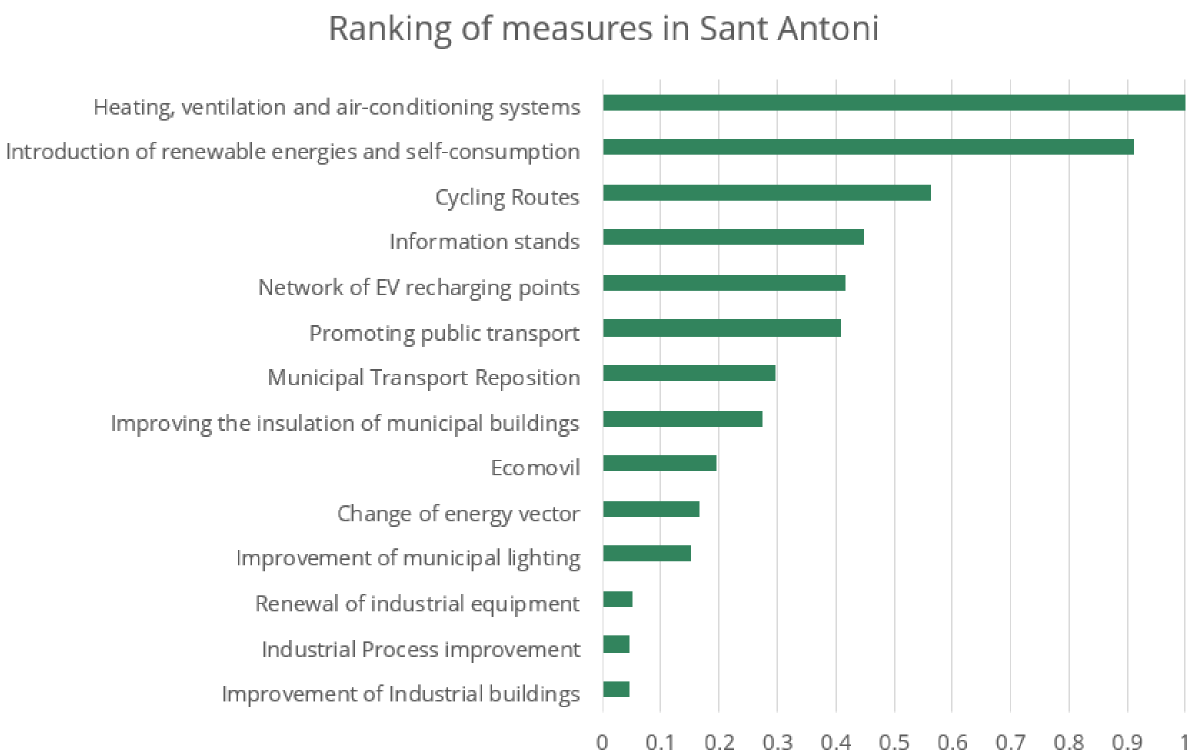


Figure 46. Ranking of most promising strategies for the municipality of Sant Antoni de Portmany

3.1.2.4. Ranking of the most promising strategies in Sant Antoni

In summary, the most promising strategies for the municipality of Sant Antoni de Portmany are presented with the associated energy savings and emissions mitigation results. This would be the report provided by the GENERA tools for policy makers according to the defined actions and their evaluation criteria.

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS ($tCO2e$)	CATEGORY
1	Heating, ventilation and air-conditioning systems-	16.23	7.51	Municipal facilities
2	Introduction of renewable energies and self-consumption	56.10	25.24	Municipal facilities
3	Cycling Routes	-	856.10	Transport
4	Information stands	33.55	77.22	Awareness
5	Network of EV recharging points	-	2931.68	Transport
6	Promoting public transport	-	37.86	Transport
7	Municipal Transport Reposition	-	18.93	Municipal facilities
8	Improving the insulation of municipal buildings	1056.95	475.63	Municipal facilities
9	Ecomovil	-	-	Awareness
10	Change of energy vector	-	-	Industry

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO2e)	CATEGORY
11	Improvement of municipal lighting	1.95	0.88	Municipal facilities
12	Renewal of industrial equipment	-	-	Industry
13	Industrial Process improvement	-	-	Industry
14	Improvement of Industrial buildings	-	-	Industry
	TOTAL	1164.78	4430.95	

Table 3. Most promising strategies in Sant Antoni and estimated associated energy and emissions reductions

Although the ranking of measures includes actions such as those related to the industry sector, these have not been considered in the plan due to the fact that in the short term there are no plans to take measures in this area. However, some measures such as the change of energy vector may be of interest from the municipality due to the need to introduce renewable energies in the municipality. This is why this measure is ahead of the improvement of lighting. It could be considered as an improvement in a future edition of the tool.

3.1.3. Pilot 2 in Tenerife (Canary Islands): El Rosario

3.1.3.1. Features of El Rosario

The municipality has a total of 17,983 inhabitants and its municipal area covers an area of 39.43 square kilometers. It occupies an intermediate position with respect to the size of the rest of the municipalities of the Island (it is larger than 12 of the 31 municipalities of Tenerife) it has a population density of 276 inhabitants per square kilometer [4]. Among its characteristics, the confluence of two very different climates, product of the morphological conditions of the municipality, and the action or absence of the regime of the trade winds, have been decisive for the conformation of its models of development throughout time.

The city council of El Rosario (Tenerife) signed on May 15, 2013 the adhesion to the Covenant of Mayors. The main commitments they assumed were:

Section	Objective
CO_2 emissions	Reduce CO_2 emissions, in their respective territorial areas, by at least 20%, through the implementation of a Sustainable Energy Action Plan.

Table 4. Municipal objectives of El Rosario

3.1.3.2. Summary of actions of El Rosario

After a detailed study of the actions included in the municipality of El Rosario at the municipal level and, specifically, in the Covenant of Mayors for Climate and Energy, for the creation and updating of the Action Plan [5], the measures are introduced in the GENERA tool for the evaluation of alternatives. The actions have been considered according to the different sections detailed in the inference module.

Municipal Buildings And Public Facilities

- **Improving energy efficiency in municipal buildings**

It is proposed to improve the energy efficiency of buildings, specifically of a total of 7. To this end, the tool allows improving the building envelopes such as windows an insulation. In relation to the windows, a change with double glazing is proposed, which will improve the energy consumption of the buildings. An average of 600 square meters per building is estimated, with 12% of windows. On the other hand, glass wool is added to the insulation on different surfaces.

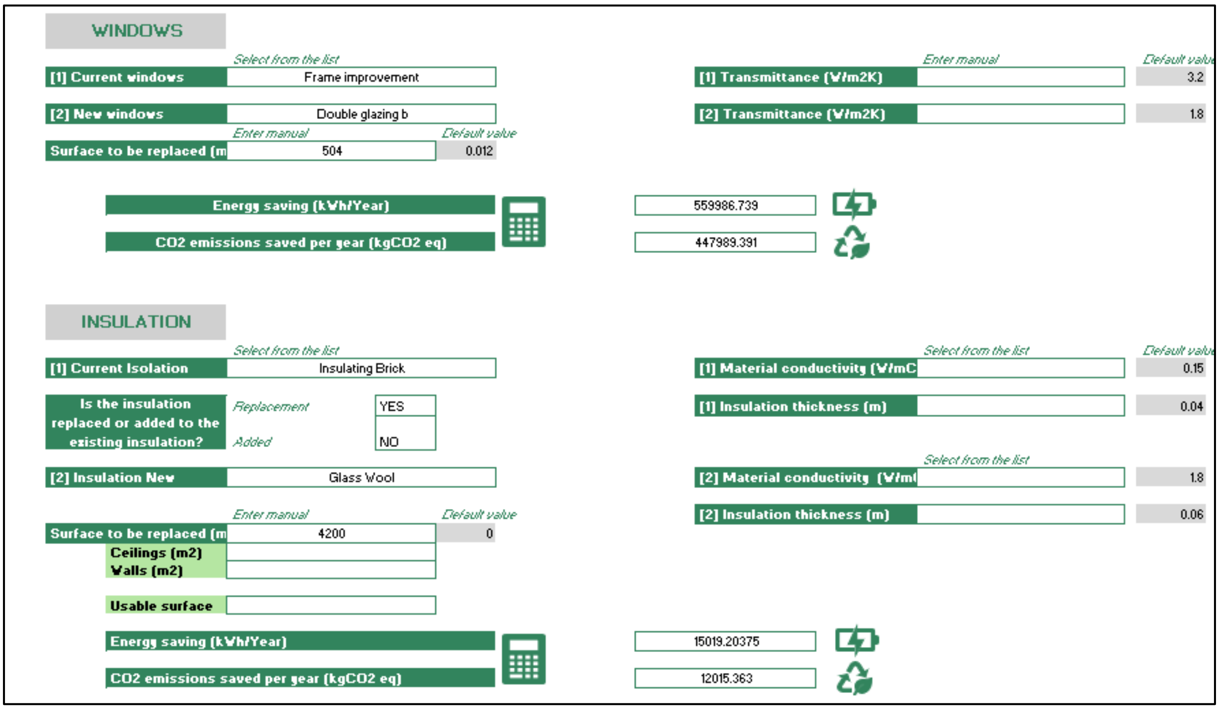


Figure 47. Improving the envelope of El Rosario's public buildings

- **Indoor lighting renovation**

Improved energy efficiency in public buildings by changing luminaires for LEDs, and in streets, incandescent lamps for LEDs in traffic lights.

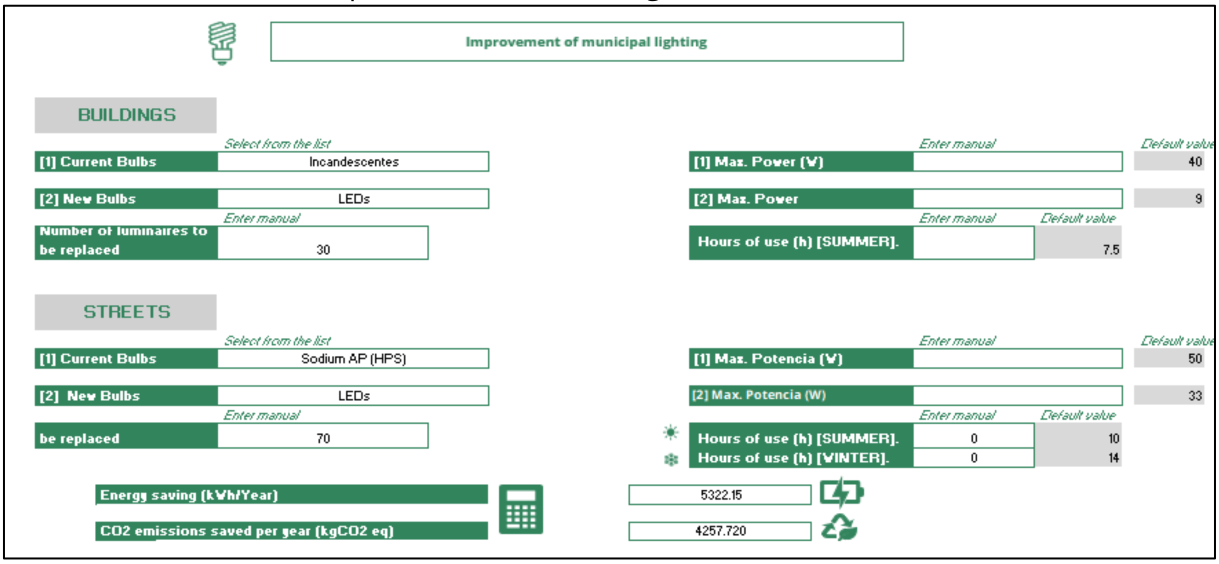


Figure 48. Change of lighting fixtures in public buildings and streets in El Rosario

- **Improvement of building conditioning**

Among the proposals of the city council is the improvement of the energy efficiency of the buildings, for which the improvement of the air conditioners is proposed, improving their energy labeling as shown below.

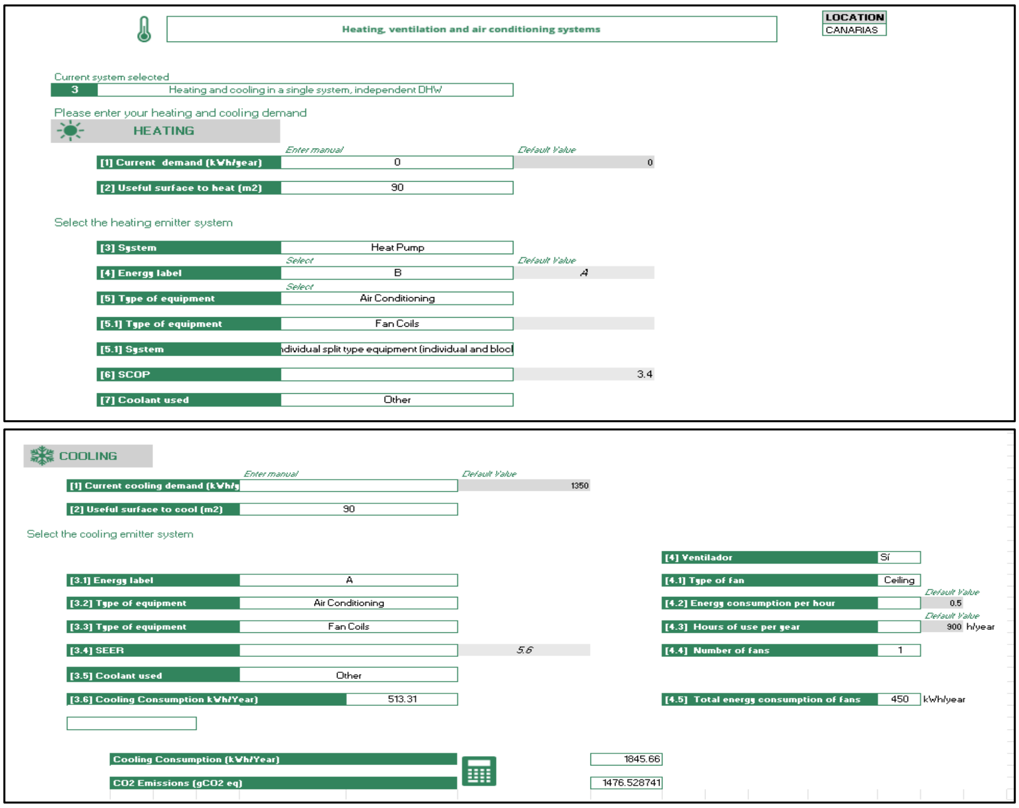


Figure 49. Calculation of the previous heating and cooling system in El Rosario

The same system is then calculated but improving the energy certificate of the air conditioning equipment, as shown in the following figure. It is assumed that the domestic hot water system is independent.

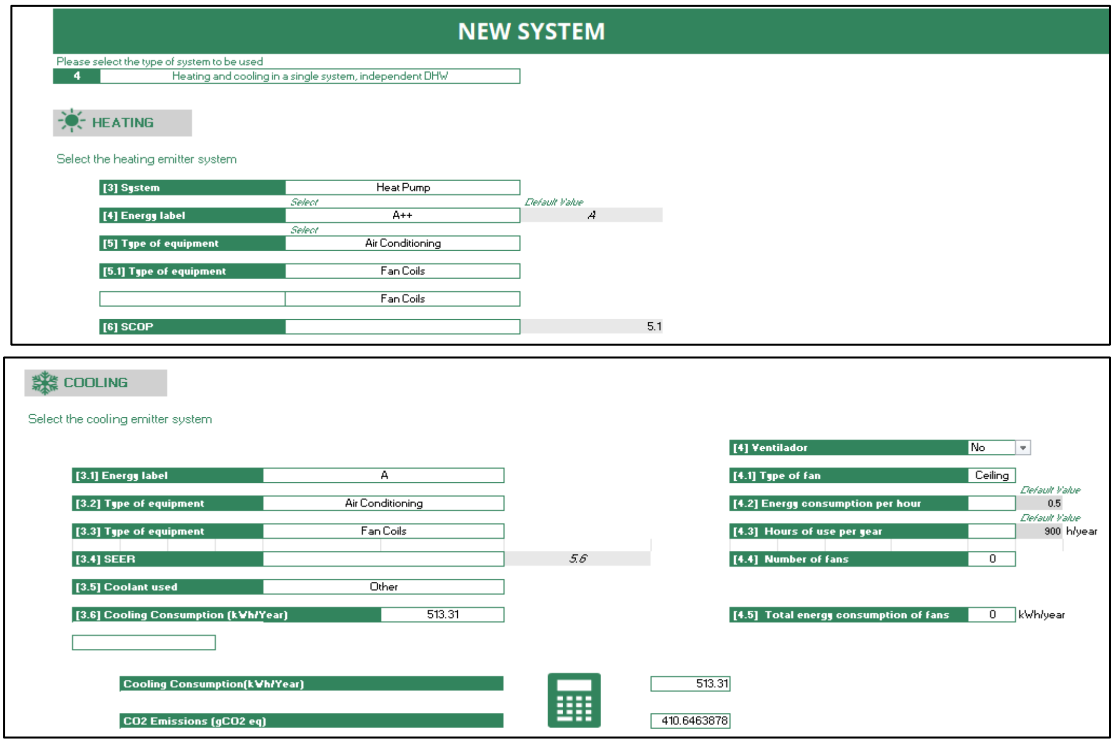


Figure 50. Calculation of the new heating and cooling system in El Rosario

Finally, the summary of the energy saved by the improvement of the equipment is shown, as well as the emissions saved.

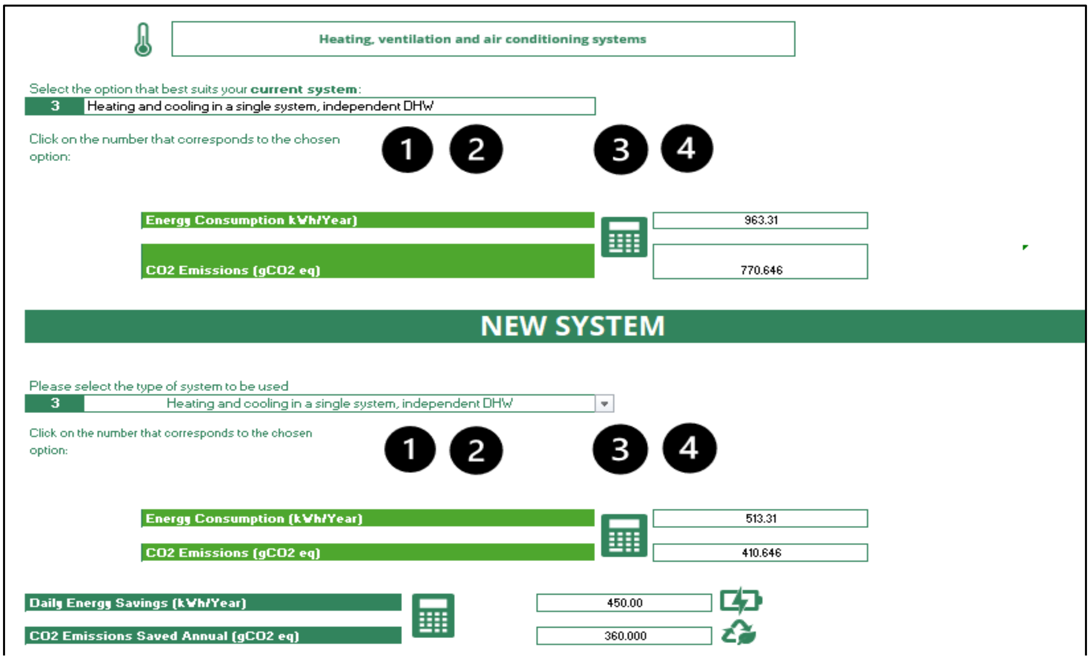


Figure 51. Energy and CO_2 emissions savings from improved air conditioning in El Rosario

- **Introduction of renewable energies in public buildings**

Among the main actions proposed at the municipal level are the installation of solar thermal energy in municipal buildings, according to the square meters available, and the installation of solar photovoltaic energy.

The first step is to enter the data of the buildings, and the information to enter the solar thermal energy considering the available area of the collectors.

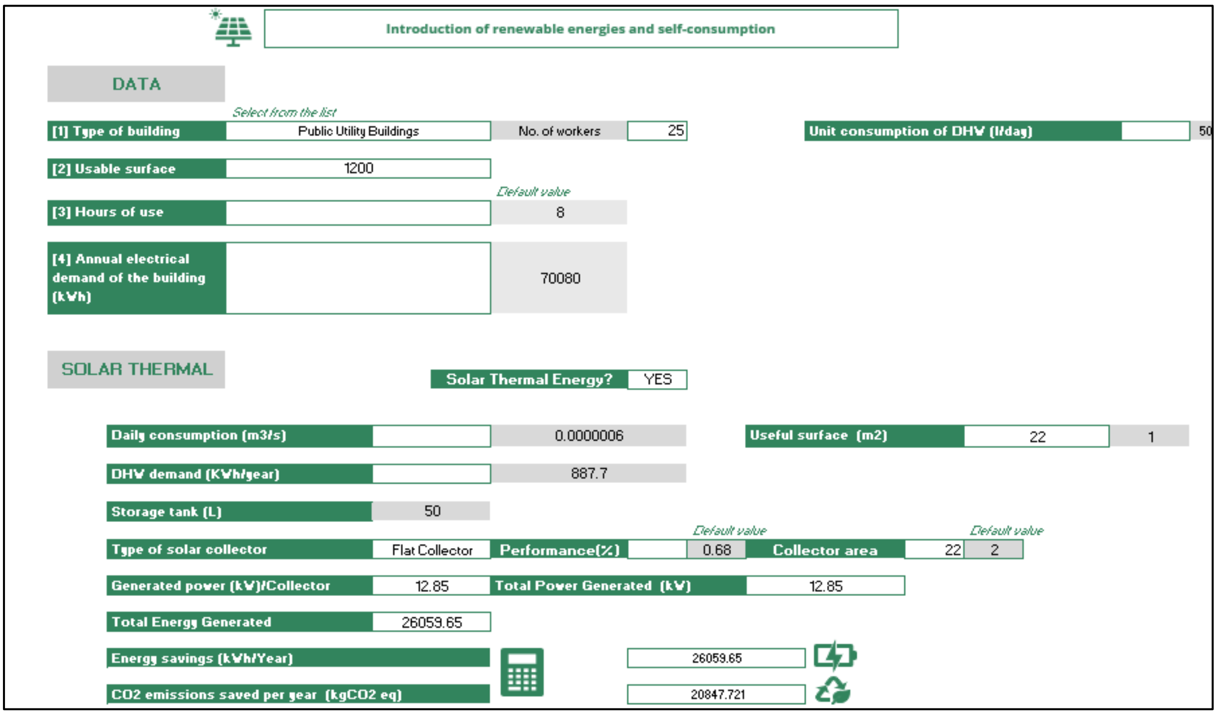


Figure 52. Installation of solar thermal energy in municipal buildings in El Rosario.

On the other hand, solar energy is also introduced for electricity production. In this case, monocrystalline panels with higher efficiency and 40W power are used. The use of batteries for energy storage is not analyzed.

Finally, it is also intended to better manage municipal composting through the use of prunings. A quantity of prunings of 1000kg is foreseen for use in the anaerobic digester.

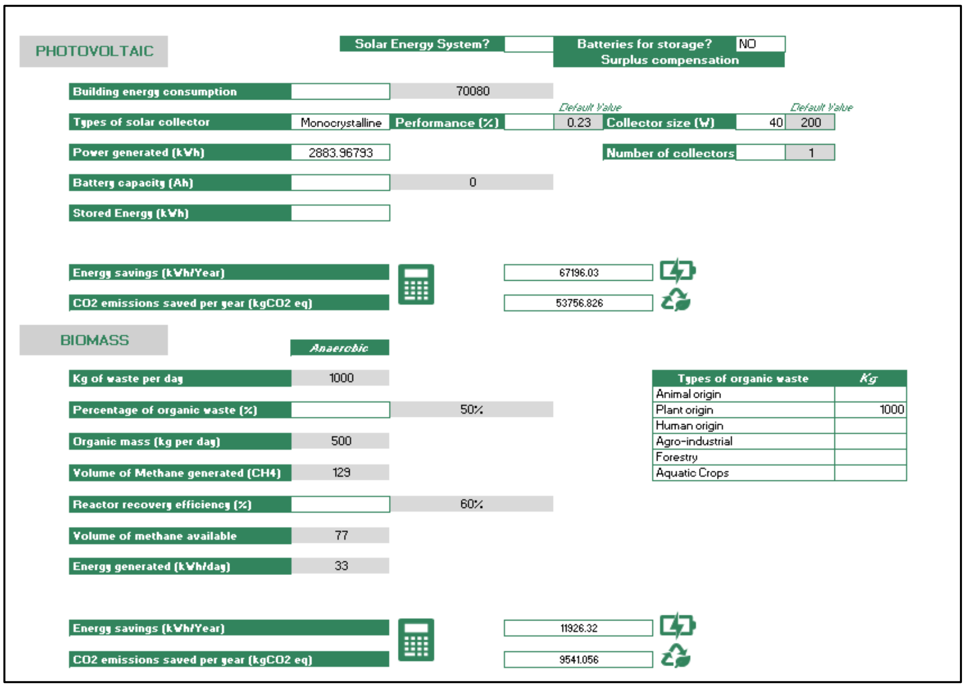


Figure 53. Photovoltaic and biomass solar energy installation in El Rosario

- **Renewal of municipal fleet of energy efficient vehicles**

Finally, the last action considered at the municipal level is to renew the fleet of vehicles for more efficient ones, such as electric vehicles. In this case, all gasoline vehicles (a total of 10 vehicles) will be replaced by electric vehicles.

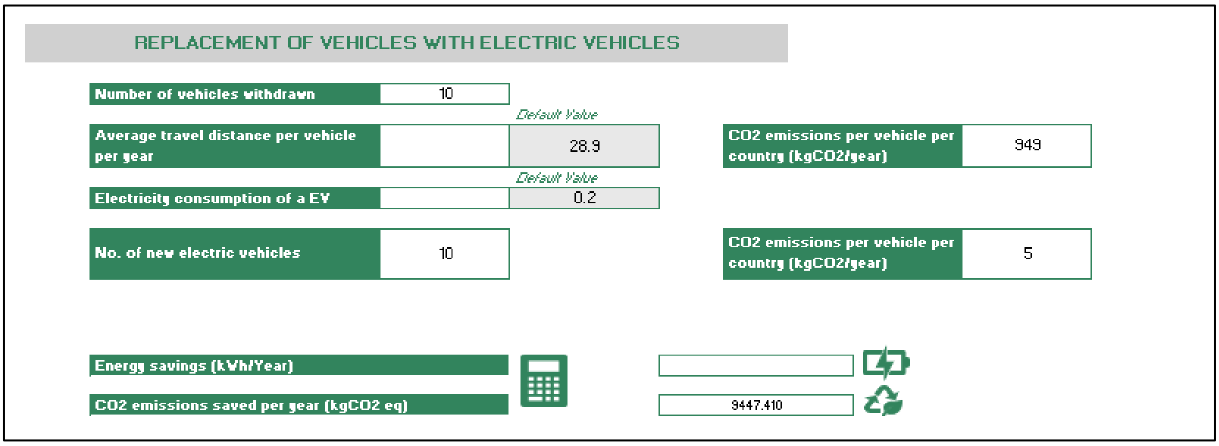
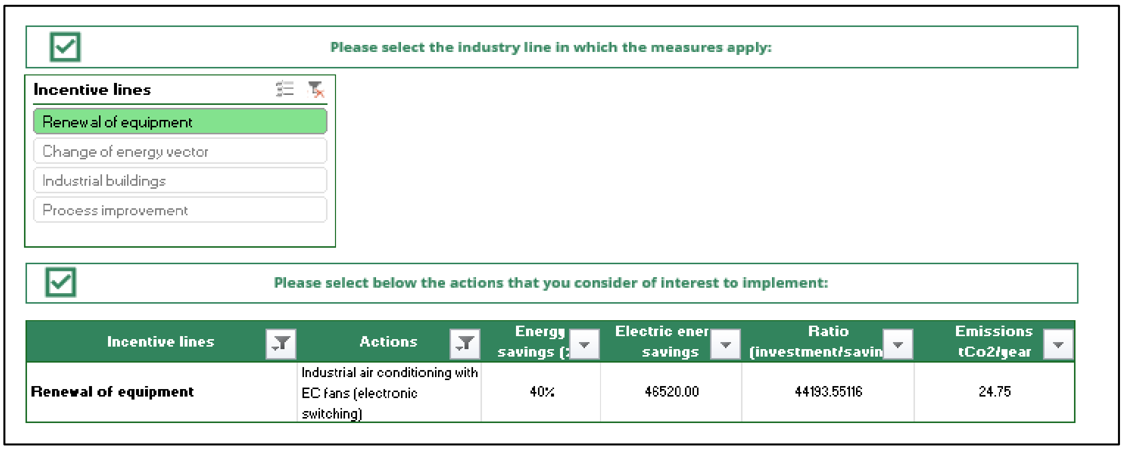


Figure 54. Replacing vehicles with more efficient ones in El Rosario

Industry

Promotion of energy consumption control in companies, e.g. industrial air conditioning with EC (electronically commuted) fans.



Incentive lines	Actions	Energy savings (%	Electric ener savings	Ratio (investment/savin	Emissions tCo2/year
Renewal of equipment	Industrial air conditioning with EC fans (electronic switching)	40%	46520.00	44193.55116	24.75

Figure 55. Improving energy efficiency in businesses in El Rosario

Transport

- **Increased bicycle lane line**

Among the main actions is the creation of a mobility plan for the improvement of municipal transportation. This plan indicates the km of bike lanes to be extended, in this case it is proposed to include 5 km of lanes that will save CO_2 emissions according to the figure below.

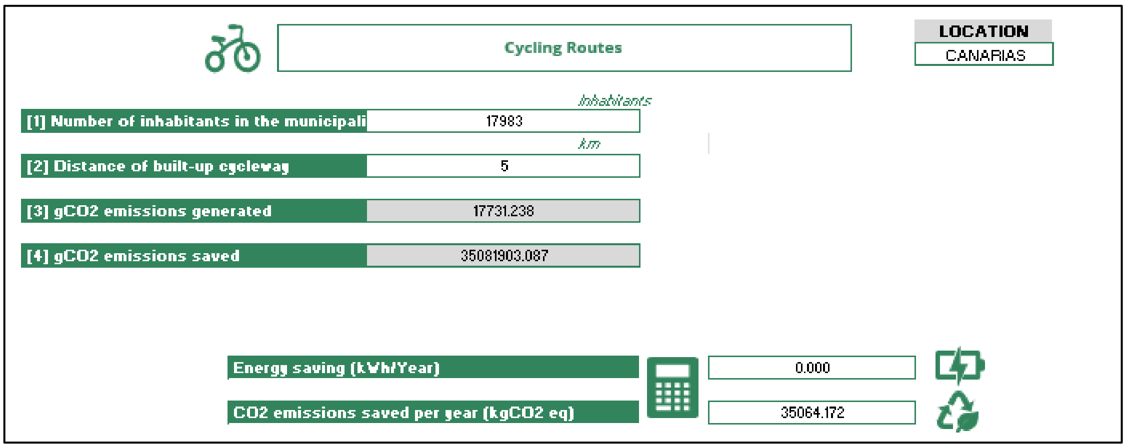
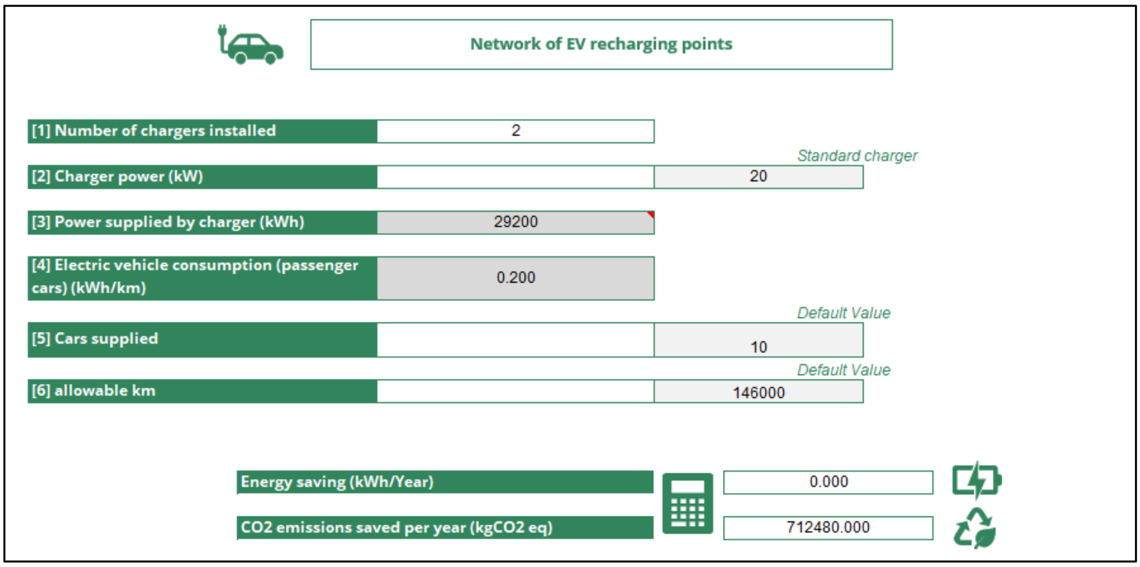


Figure 56. Emissions saved by the inclusion of bike lanes in El Rosario

- **Implementation of alternative recharging points**

Including recharging points to provide alternative options to conventional vehicles is another priority action. In this case, it is proposed to introduce 2 electric vehicle recharging points.



Network of EV recharging points

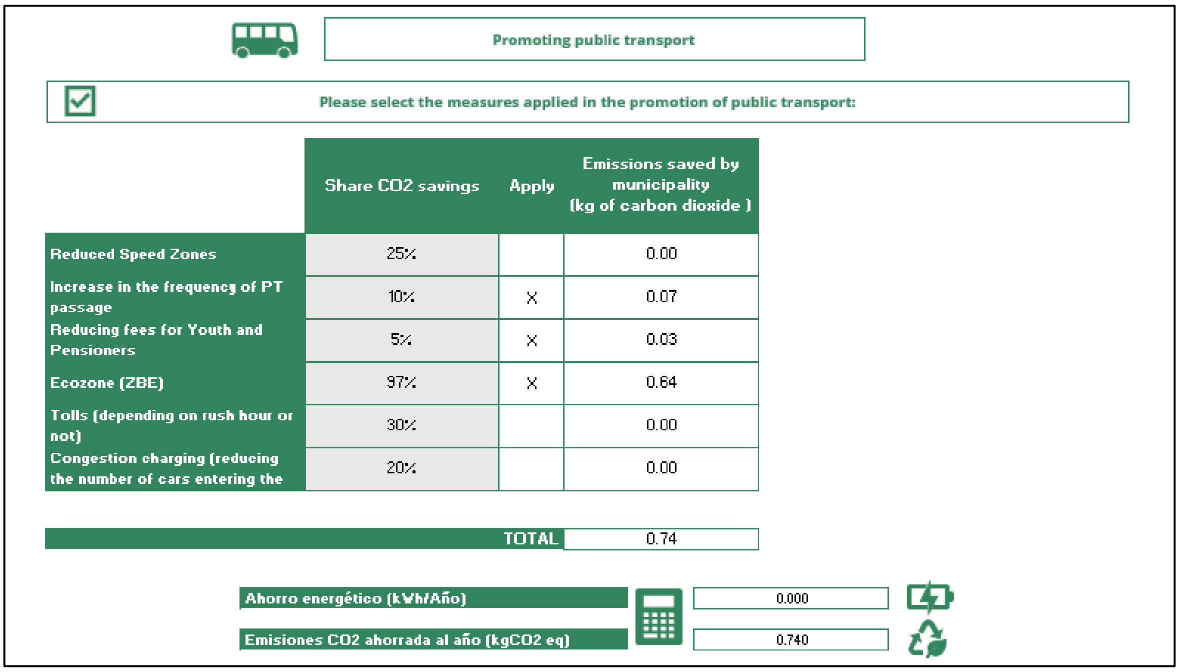
[1] Number of chargers installed	2		
[2] Charger power (kW)		20	Standard charger
[3] Power supplied by charger (kWh)	29200		
[4] Electric vehicle consumption (passenger cars) (kWh/km)	0.200		
[5] Cars supplied		10	Default Value
[6] allowable km		146000	Default Value

Energy saving (kWh/Year)	0.000
CO2 emissions saved per year (kgCO2 eq)	712480.000

Figure 57. Creation of EV recharging points in El Rosario

- **Actions to promote public transport**

Finally, some measures to promote public transport are introduced to help citizens become aware and take action. Some actions are the improvement of public transport by increasing frequency, reduced rates for young people and adults or the creation of a low emission zone.



Promoting public transport

Please select the measures applied in the promotion of public transport:

	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%		0.00
Increase in the frequency of PT passage	10%	X	0.07
Reducing fees for Youth and Pensioners	5%	X	0.03
Ecozone (ZBE)	97%	X	0.64
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the	20%		0.00
TOTAL			0.74

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	0.740

Figure 58. Actions to promote public transport in El Rosario

Awareness

Citizen awareness actions in El Rosario are directly aimed at the creation of a municipal awareness and training plan. They also include training in schools, collection points and training workshops for recycling and energy consumption reduction strategies. In addition, discount rates are also applied for homes with self-consumption or for construction works with bioclimatic solutions. The following figure shows the different measures with the consequent energy savings and emissions mitigated by their application.

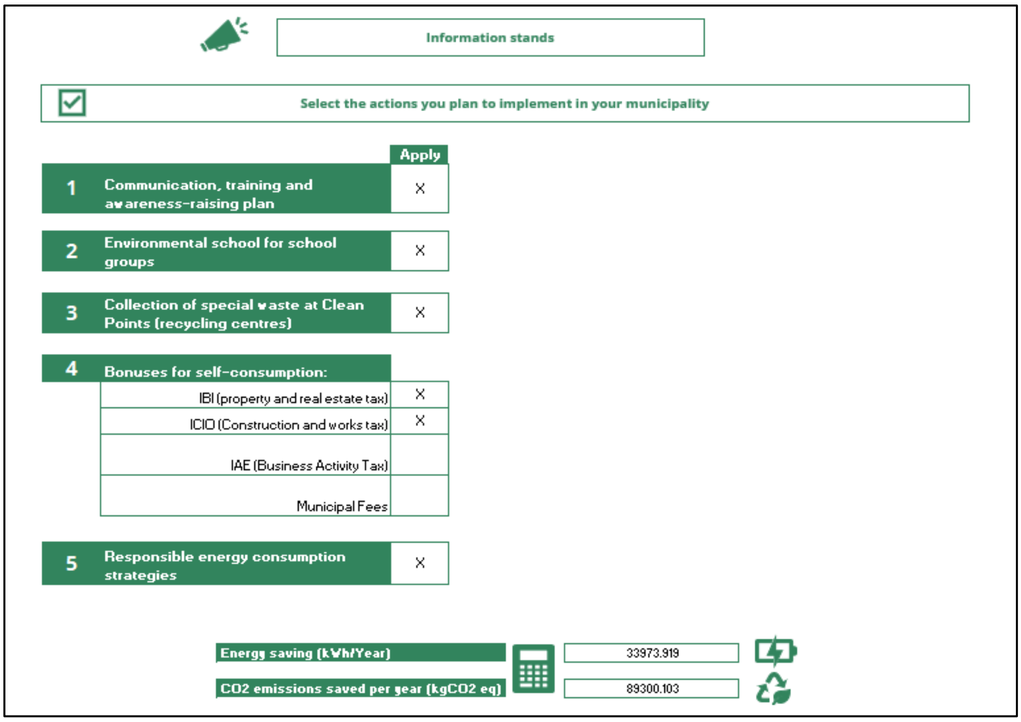


Figure 59. Citizen awareness measures in El Rosario

3.1.3.3. Multicriteria Decision in El Rosario

Considering the priorities established by the municipality, the criteria used to prioritize the different levels are as follows:

- Conducting energy audits in municipal buildings and schools.
- Improvements in the equipment and infrastructure of the public lighting network, through the replacement of more efficient switchboards, luminaires and lamps.
- Municipal tax rebates for the use of renewable energies and energy efficient vehicles.
- Use of renewable energies: use of biogas energy generated by the contribution of waste at the provincial landfill, installation of photovoltaic plants and solar thermal installations.
- Intention to set up a permanent personalized attention and advice department for individuals and legal entities interested in energy saving and the use of renewable energy sources.

The assessments are introduced in the chosen software applying the AHP method and a final report is obtained, suitable for the municipality of El Rosario.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0183	0.0558	0.2764	8
	CA1.2 Improvement of municipal lighting	0.0262	0.0799	0.3959	6
	CA1.3 Heating, ventilation and air-conditioning systems	0.0342	0.1043	0.5169	4
	CA1.4 Introduction of renewable energies and self-consumption	0.0661	0.2017	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0081	0.0246	0.1220	10
	CA2.1 Industrial Process improvement	0.0035	0.0107	0.0529	14
	CA2.2 Renewal of industrial equipment	0.0039	0.0119	0.0590	12
	CA2.3 Improvement of Industrial buildings	0.0036	0.0109	0.0539	13
	CA2.4 Change of energy vector	0.0082	0.0251	0.1242	9
	CA3.1 Cycling Routes	0.0376	0.1146	0.5683	3
	CA3.2 Network of EV recharging points	0.0230	0.0702	0.3478	7
	CA3.3 Promoting public transport	0.0276	0.0842	0.4174	5
	CA4.1 Ecomovil	0.0057	0.0173	0.0855	11
	CA4.2 Information stands	0.0620	0.1890	0.9371	2

Figure 60. Report on alternatives obtained for the municipality of El Rosario

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

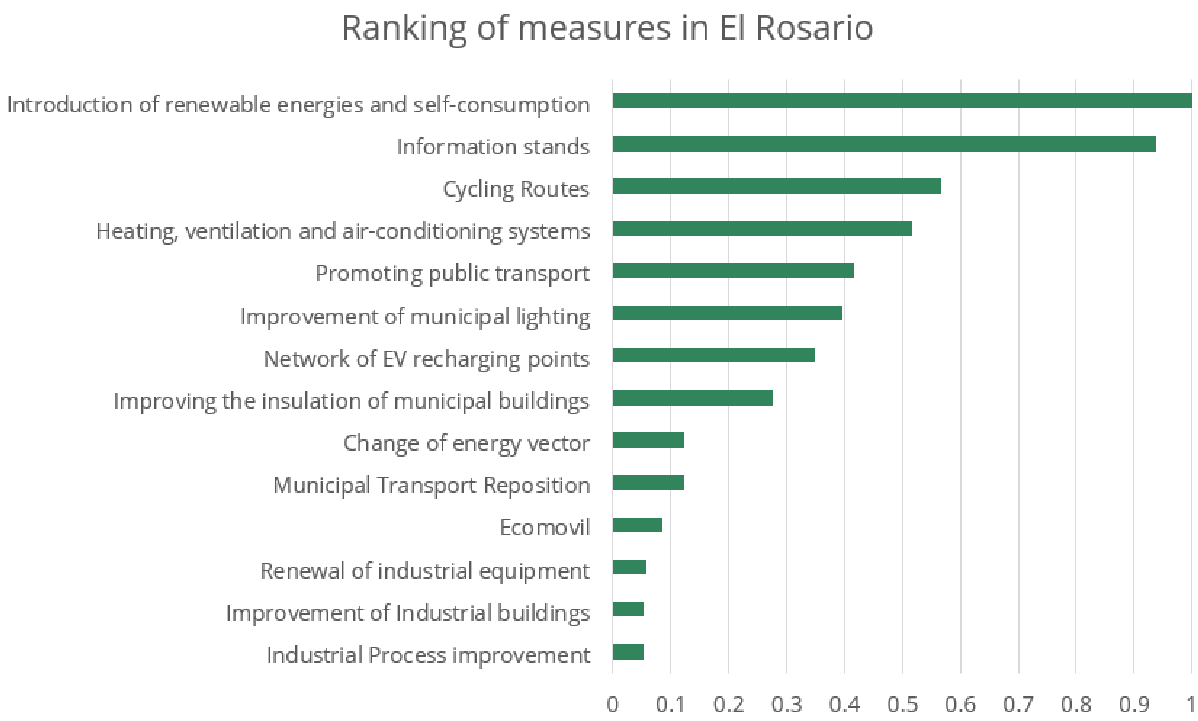


Figure 61. Ranking of most promising strategies for the municipality of El Rosario

3.1.3.4. Ranking of the most promising strategies in El Rosario

In summary, the most promising strategies for the municipality of El Rosario are presented with the associated energy savings and emissions mitigation results. This would be the report provided by the GENERA tools for policy makers according to the defined actions and their evaluation criteria.

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
1	Introduction of renewable energies and self-consumption	105.18	84.15	Municipal facilities
2	Information stands	33.94	89.30	Awareness
3	Cycling Routes	-	35.06	Transport
4	Heating, ventilation and air-conditioning systems	0.45	0.36	Municipal facilities
5	Promoting public transport	-	13.30	Transport
6	Improvement of municipal lighting	5.32	4.26	Municipal facilities
7	Network of EV recharging points	-	712.50	Transport
8	Improving the insulation of municipal buildings	567.45	453.96	Municipal facilities
9	Change of energy vector	-	-	Industry
10	Municipal Transport Reposition	-	9.45	Municipal facilities
11	Ecomovil	-	-	Awareness
12	Renewal of industrial equipment	46.52	37.22	Industry
13	Improvement of Industrial buildings	-	-	Industry
14	Industrial Process improvement	-	-	Industry
	TOTAL	758.86	1439.20	

Table 5. Most promising strategies in El Rosario and estimated associated energy and emissions reductions

In this case, the municipal measures are mainly obtained first, together with those of awareness and transportation. In the last place are those related to industry, although there are measures related to the renewal of equipment in the tertiary or industrial sector. The energy vector appears after making the comparison in the AHP for including renewable energies and other non-conventional systems in the process, and these are municipal priorities, even though they are not included as specific actions.

3.2. Italy

Italy, like Spain, is characterized by lower per capita electricity consumption and lower mineral depletion, and its electricity generation from renewable sources is very similar, at around 45% [1].

In relation to the situation of the Italian islands, Sicily is characterized by a large population that contrasts with a low population density (larger territory). Its employability rate is low and its economy is less dependent on tourism than in other Mediterranean regions. The island of Sardinia is characterized by a low population and population density, which translates into a good employment rate; however, it is not highly dependent on tourism.

3.2.1. Study of the Italian National Context

This section presents an analysis of the energy context of Italy using module 1 of the GENERA tool. As in the case of Spain, the reference data are taken from the year 2023, which is the year for which complete information is available. The Italian energy mix for energy supply is mainly characterized by natural gas (38.1%) with values similar to oil (37.5%), followed by biofuels and waste (10.5%) and continued by geothermal, solar and wind energy, coal and hydropower. CO_2 emissions in Italy have been reduced by 26% compared to 2000 data, making Italy an emitter of 0.91% of world emissions.

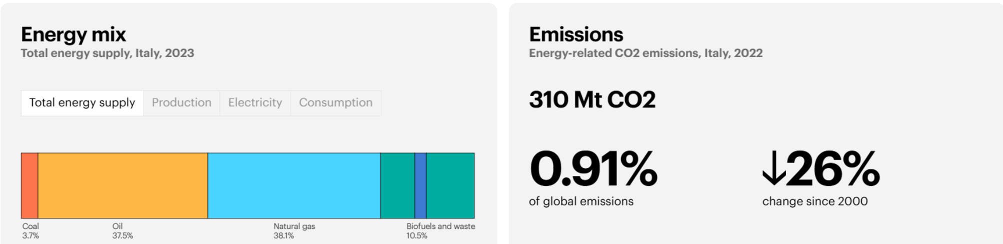


Figure 62. Summary of Italy's energy mix and emissions. Source: https://www.iea.org/countries/italy

Using Module 1 of the GENERA tools, 2022 reference data are introduced (since 2023 is incomplete for some sectors) and come from the International Energy Agency [1].

Figure *63* shows the contribution of each energy source in the main sectors of the Italian economy such as transport, industry, residential, services and others (agriculture, fishing, etc.), including electricity generation.

In Italy, the use of fossil fuels such as oil stands out, mainly for the transport and agriculture/fishing sectors, and natural gas for the industrial, residential and services sectors, as well as electricity generation. In addition, there is also special relevance of renewables in the residential sector. On the other hand, they have practically no coal and no contribution from nuclear energy.

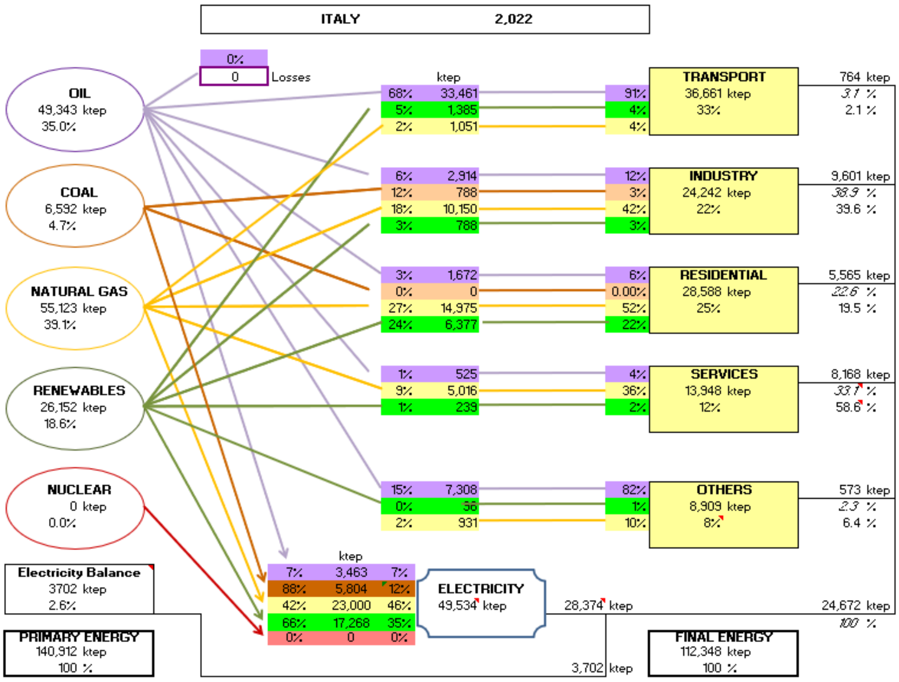


Figure 63. Energy balance of the different energy sources and sectors in Italy

The main indicators such as primary energy demand, electricity generation and emissions up to 2030, following current trends, are presented in the following figures.

Figure *64* below shows the data on primary energy demand in the current Italian system. As can be seen in the figure, the contribution is very stable over the years, with the main involvement of natural gas and oil. This is followed by renewables and coal and nuclear. The figure shows a subtle increase in natural gas and renewables, which could be increased by implementing sustainable policies.

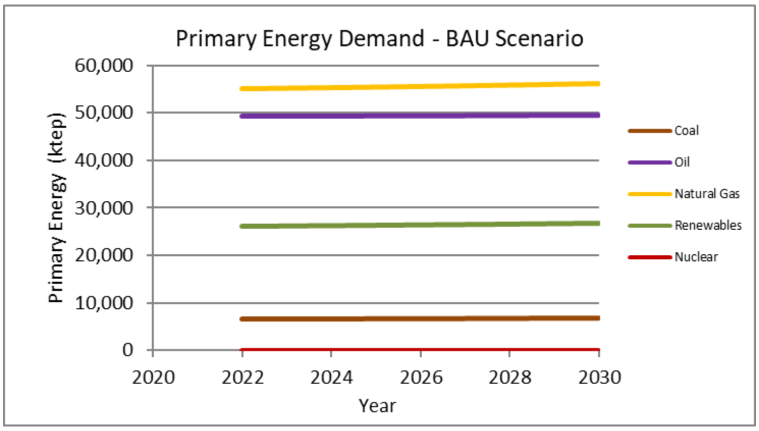


Figure 64. BAU Italy Scenario: Primary Energy Demand

The figure below shows the contribution of each source to Italy's electricity generation, which is mainly based on natural gas followed by renewable energy. These are the main sources of electricity production. Also noteworthy is the growing generation by renewable energy, which will continue to grow and, if measures are implemented, could even increase. The next sources that contribute to a lesser extent are coal and oil. Finally, there is no contribution from nuclear energy in Italy.

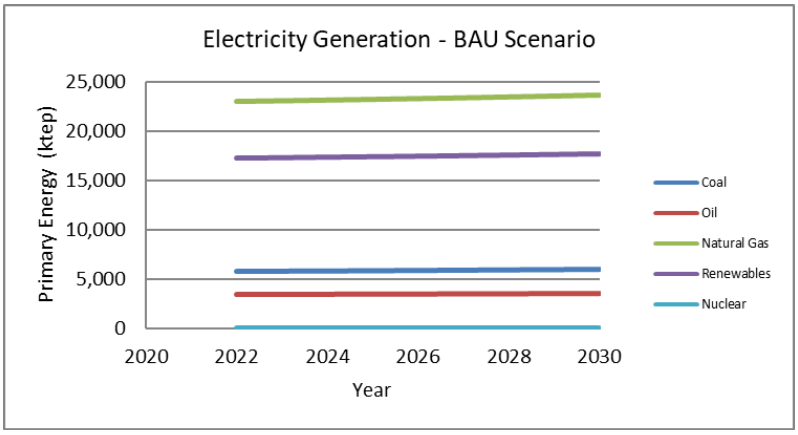


Figure 65. BAU Italy Scenario: Electricity Generation

Finally, the CO_2 emissions produced in Italy by each sector are shown. The main CO_2 emitting sector is electricity generation, which may be due to the 12% contribution of coal, so implementing measures to reduce it is of vital importance. This is followed by the transport sector, which could be reduced through the promotion of public transport, low emission zones, etc. The remaining emissions are mainly produced by the residential sector. Over the years, a small decreasing trend in terms of emissions can be observed in the industry and agriculture and fishing sectors. The sector that contributes the least is the services sector.

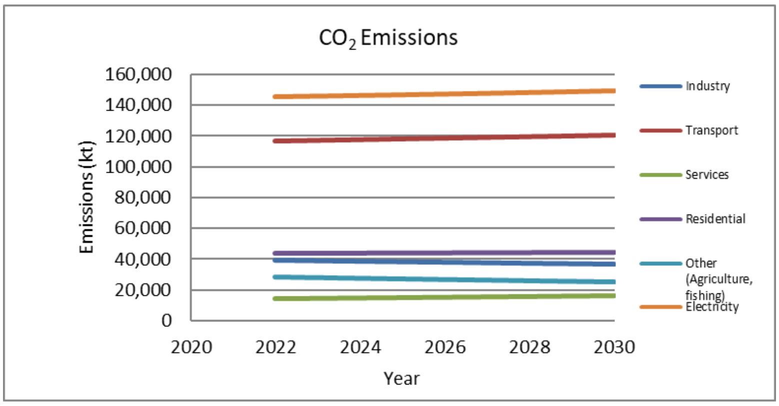


Figure 66. BAU Italy Scenario: CO_2 Emissions

In summary, the Italian energy context is characterized by the use of natural gas and oil mainly, whose major contribution is divided between the transport and electricity generation sectors, which generate most of the country's emissions. However, they are involved in all sectors: industry, residential, services and agriculture and fishing. Renewable energies are more involved in the residential and electricity sectors. In addition, there is a growing trend in the use of renewable energies, mainly for electricity production. Natural gas also shows a growing trend and greater participation in the industrial, electricity generation, residential and services sectors. Finally, in terms of emissions, the most damaging sector is electricity generation, followed by transportation. Creating and implementing measures that encourage the use of renewable energy for electricity generation and for the transportation sector could be a goal to reduce emissions in the coming years.

3.2.2. Pilot 3 in Sardinia: Stintino

3.2.2.1. Features of Stintino

Stintino is a town in the Italian province, region of Sardinia, with 1,212 inhabitants [6]. Stintino is classified as a Climate Zone C, it is a fairly warm zone. The province of Sassari has on average 82.22 hot days (temperatures above 30°C) and 0.31 cold days (temperatures below 5°C) per year. It rains (or snows) approximately 81.12 days per year. There is very little fog during the year. Stintino receives approximately 8.2 hours of sunshine per day.

The municipality of Stintino joined the Covenant of Mayors initiative with the main objective of reducing CO_2 emissions by 20%. However, the planned actions are subdivided into the different sectors of construction, mobility, renewable energies and public awareness processes.

Section	Objective
Construction	Actions planned in relation to new buildings and the increase of existing buildings with higher performance. In addition, interventions will be carried out in sub-sectors (public and private, schools and tertiary sectors).
Mobility	Improvement of accessibility conditions in the urban area: transportation methods, bicycle lanes and pedestrian areas.
Renewable Energy	Reduced dependence on conventional energy sources.
Awareness	Implementation of awareness, training and citizen participation processes to improve sustainability and education in terms of energy consumption.

Table 6. Main sections and areas for improvement at Stintino

3.2.2.2. Summary of actions of Stintino

After a detailed study of the actions included in Stintino at municipal level and, specifically, in the Covenant of Mayors for Climate and Energy, for the creation and updating of the Action Plan [7], the measures are introduced in the GENERA tool for the evaluation of alternatives. The actions have been considered according to the different sections detailed in the inference module.

Municipal Buildings And Public Facilities

In the case of Stintino, most measures are proposed in relation to municipal buildings. This gives rise to further improvements in the tool, as it is necessary to apply each of the measures per building, so an improvement could be made that applies individually to each building, and then everything could be aggregated on a single platform.

Below is a sample of what would be the implementation of measures for one of the proposed buildings, since in many cases it is intended to implement improvements in insulation, lighting, introduction of renewables and air conditioning in different buildings in parallel.

- **Improving energy efficiency in municipal buildings**

It is proposed to improve the external insulation of the municipal library by renovating the building, adding an external cladding with 7 cm of insulation and 0.032 W/mK of thermal conductivity**.**

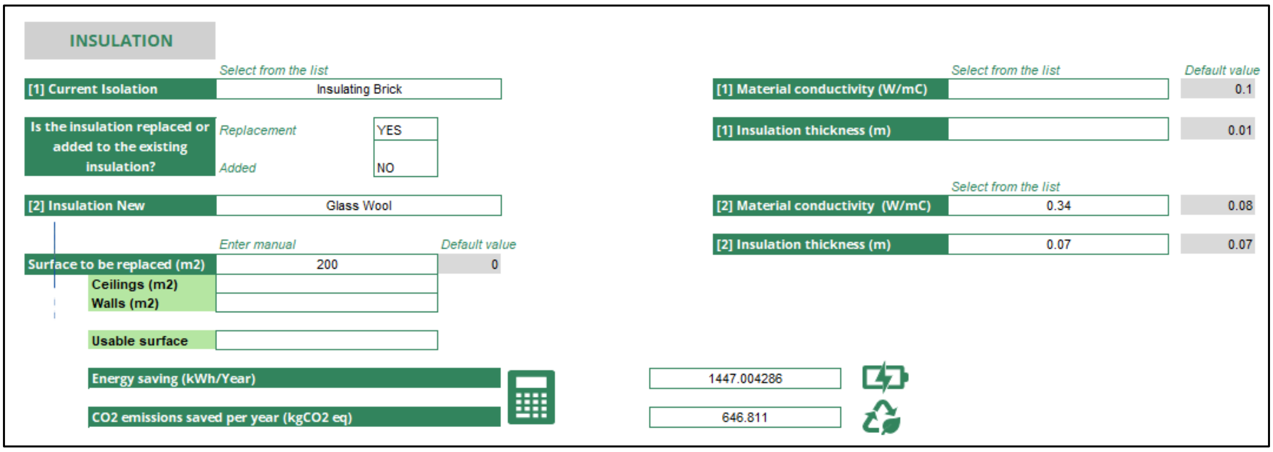


Figure 67. Improving insulation of public buildings in Stintino

- **Substitution Of Lights For More Efficient Ones**

Another of the actions to be implemented is the revision of the interior lighting, introducing more efficient ones and, if possible, introducing motion sensors. In this case, LED lights are proposed as they are the most efficient, and the possibility of introducing twilight sensors is considered. Also, sodium vapor lamps in public lighting are being replaced with more efficient LED lamps.

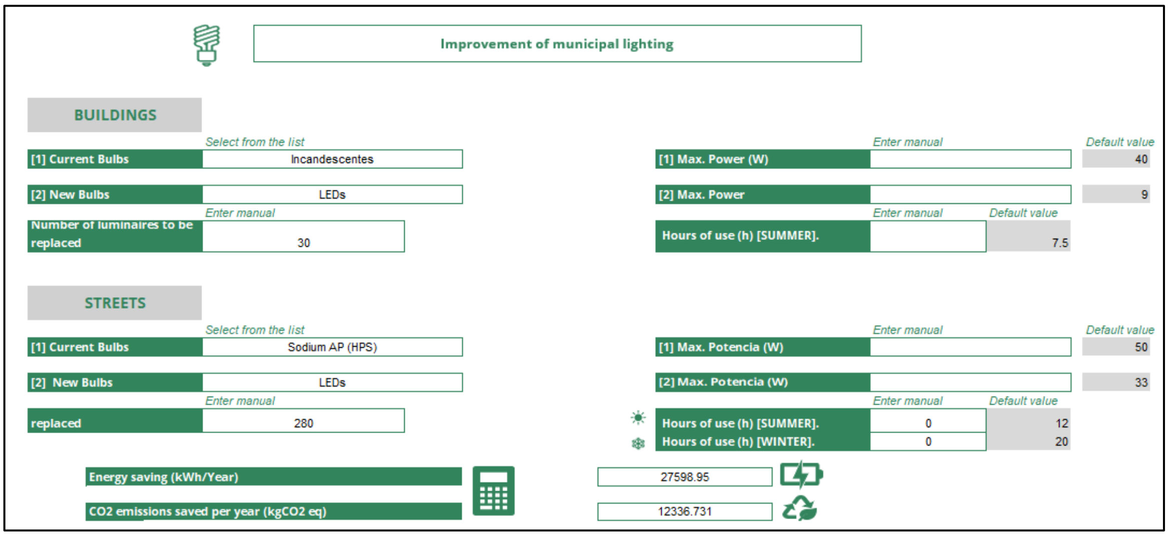


Figure 68. Improvement of luminaires in buildings and streets in Stintino

- **Improvement of building conditioning**

In relation to air conditioning, it is proposed to modify the current system in different buildings, including the gymnasium and public schools. The following is the case of the gymnasium, for which an electric water heater is replaced by a fancoil heating system consisting of a geothermal heat pump. Therefore, in primary instance, they only had an electric heater for DHW, as shown in the following figure:

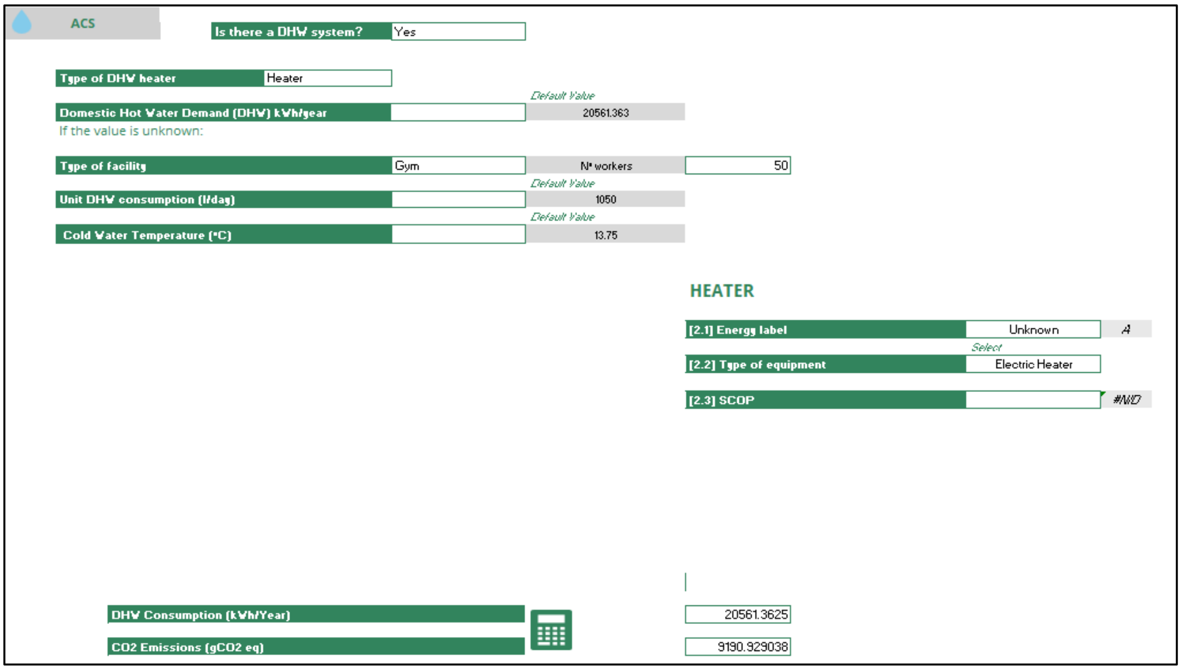


Figure 69. Energy consumption of the current DHW system in a gymnasium in Stintino

The new system has heating and DHW but uses a geothermal heat pump, and is introduced into the system as follows:

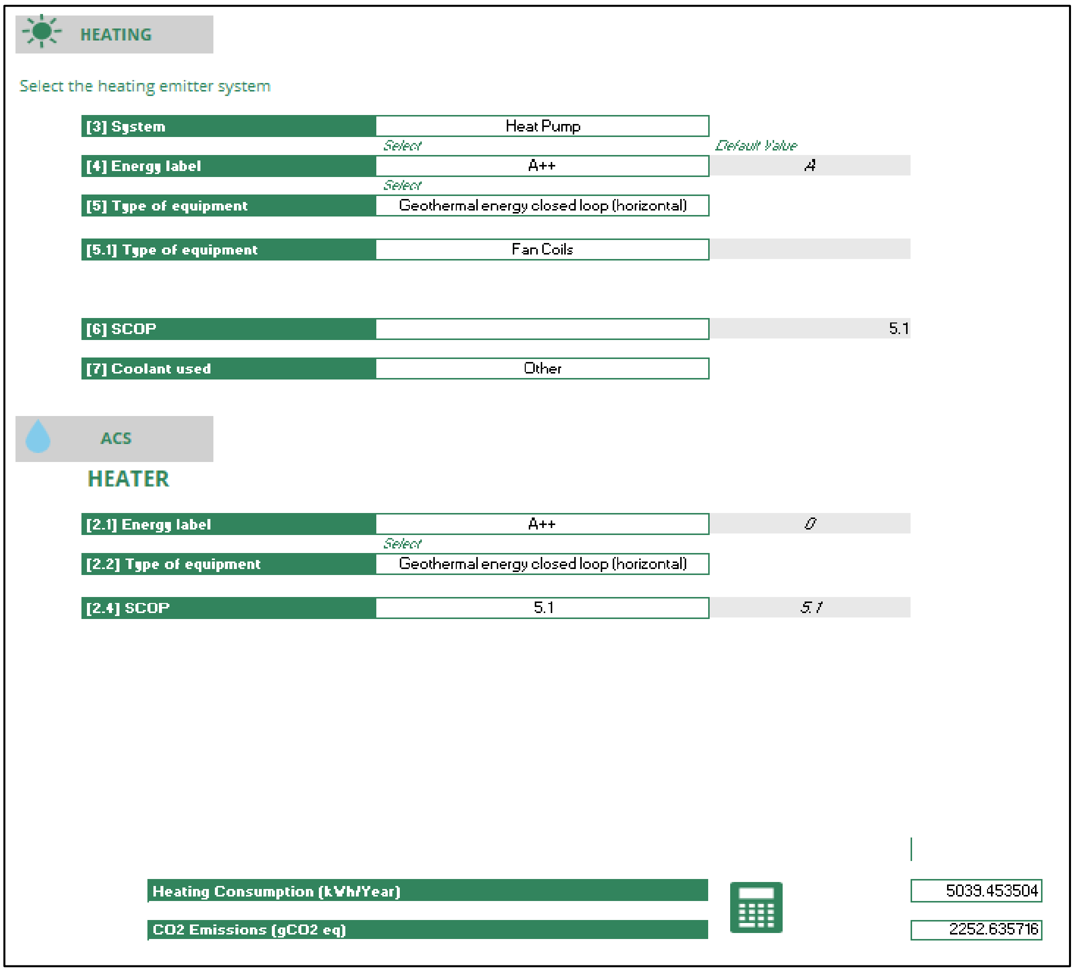


Figure 70. Energy consumption of the DHW and heating system in Stintino

Finally, the energy savings and emissions mitigated with both systems are calculated:

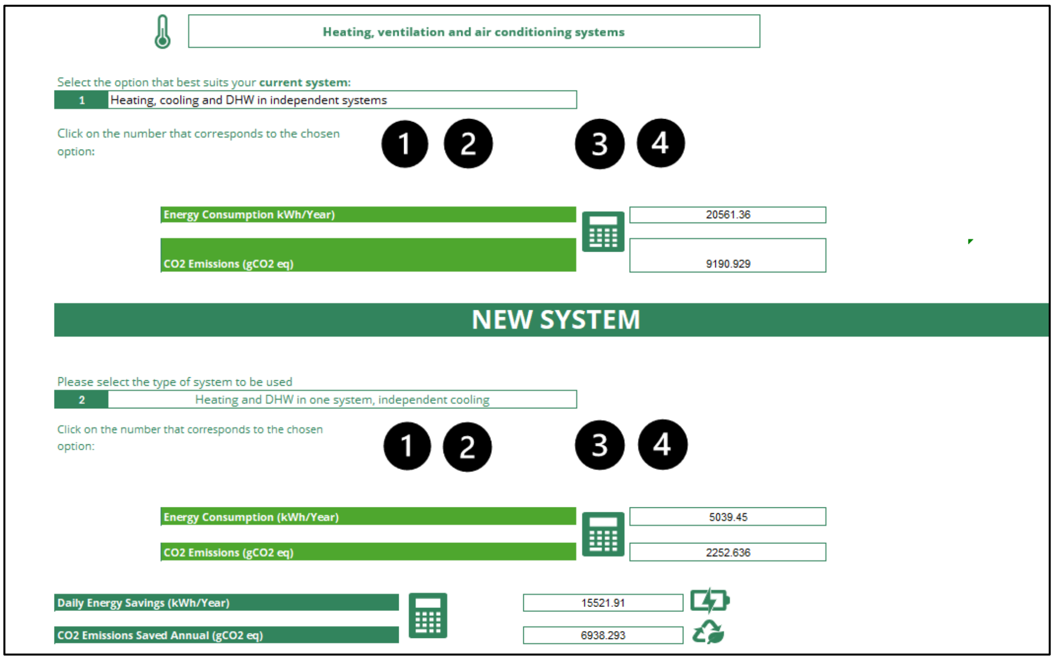


Figure 71. Energy saved by changing the air conditioning and DHW system of Stintino's buildings

- **Introduction of renewable energies in public buildings**

Another of the actions implemented in the gymnasium was the introduction of a solar thermal system for the production of DHW with a surface area of 10m2 and a 500-liter storage tank.

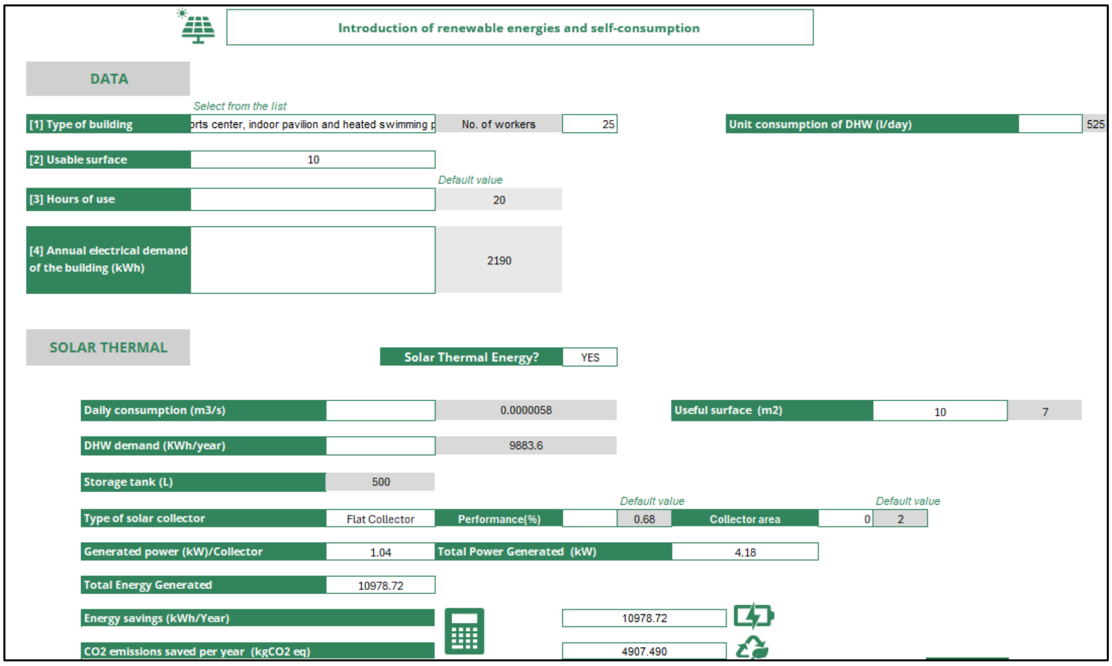


Figure 72. Introduction of solar thermal energy in Stintino public buildings

In relation to photovoltaic solar energy, energy savings of approximately 260 MWh/year are estimated, which is approximately what is obtained with this system.

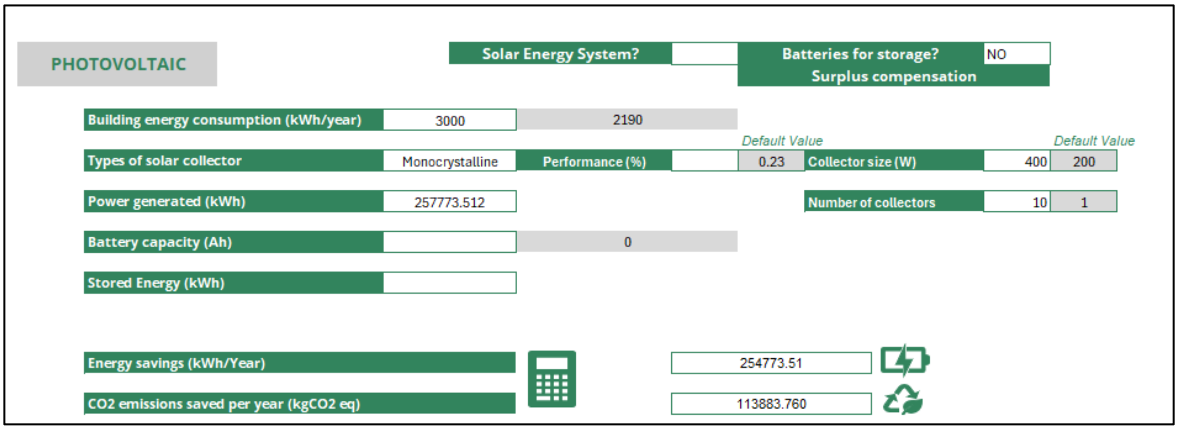


Figure 73. Introduction of photovoltaic solar energy in Stintino

- **Renewal of municipal fleet of energy efficient vehicles**

Finally, it is proposed to renew the fleet of municipal vehicles for more efficient ones such as electric vehicles. It is proposed to replace 1 vehicle.

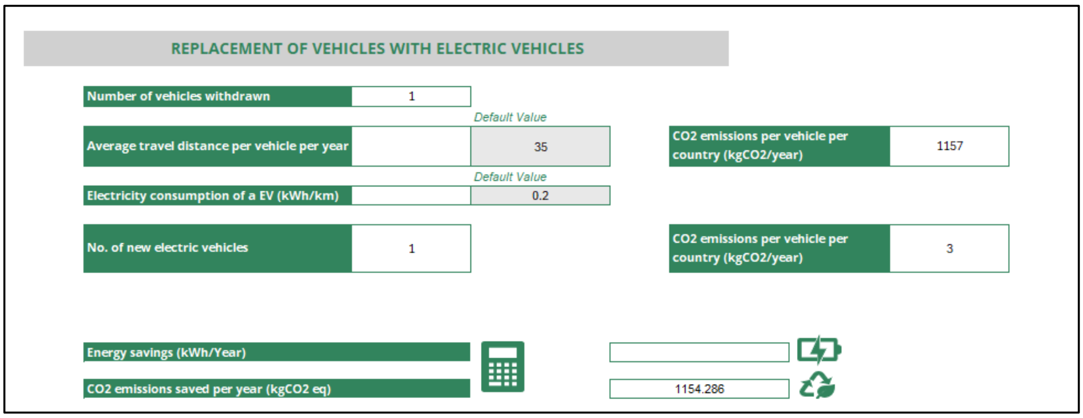


Figure 74. Introduction of electric vehicles in Stintino

Industry

In the tertiary and productive sector, measures and promotion of environmental management tools are also introduced to improve industrial buildings.

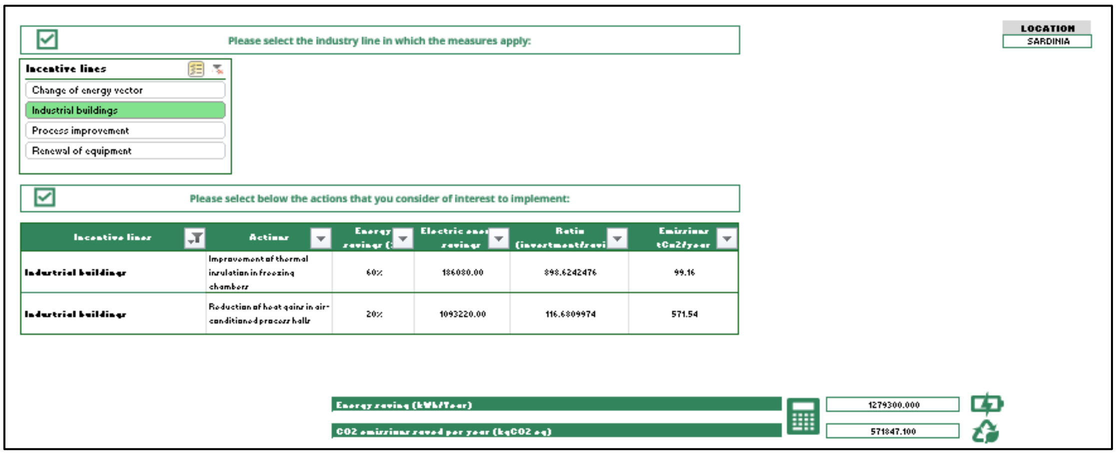


Figure 75. Improvements implemented in the industry at Stintino

Transport

The actions proposed for Stintino in relation to transportation are the creation of bike lanes to fluidify traffic, the installation of EV charging points as well as measures to promote public transport for citizens.

- **Introduction of bicycle lanes**

It is proposed to introduce a 5-km bike lane in Stintino to encourage the use of non-conventional means of transport.

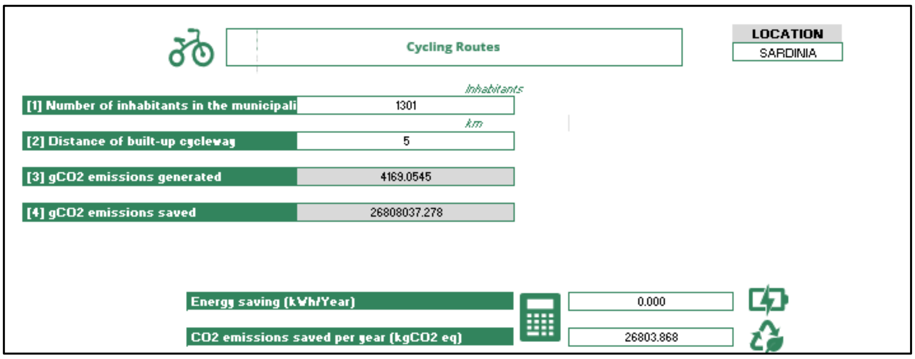


Figure 76. Promotion of bicycle lanes in Stintino

- **Introduction of an EV recharging point**

Installing an EV charging point will favor the use of non-conventional vehicles and the reduction of CO_2 emissions.

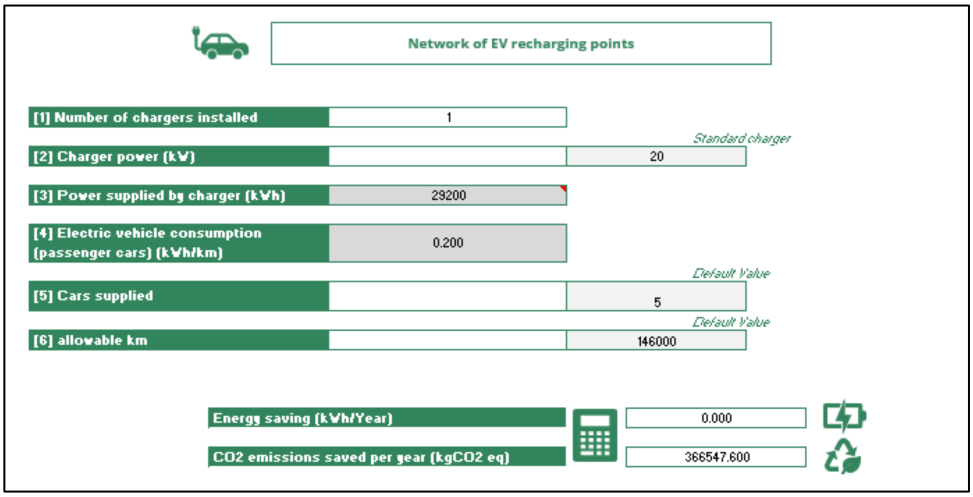
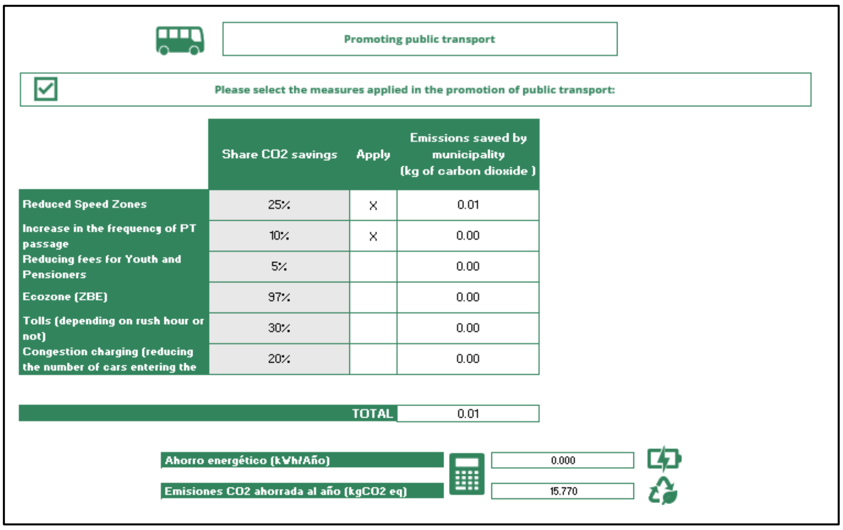


Figure 77. EV Recharging Points in Stintino

- **Promotion of public transport in Stintino**

At the transport level, it is also proposed to introduce reduced speed zones, as well as to increase the frequency of public transport.



Promoting public transport

Please select the measures applied in the promotion of public transport:

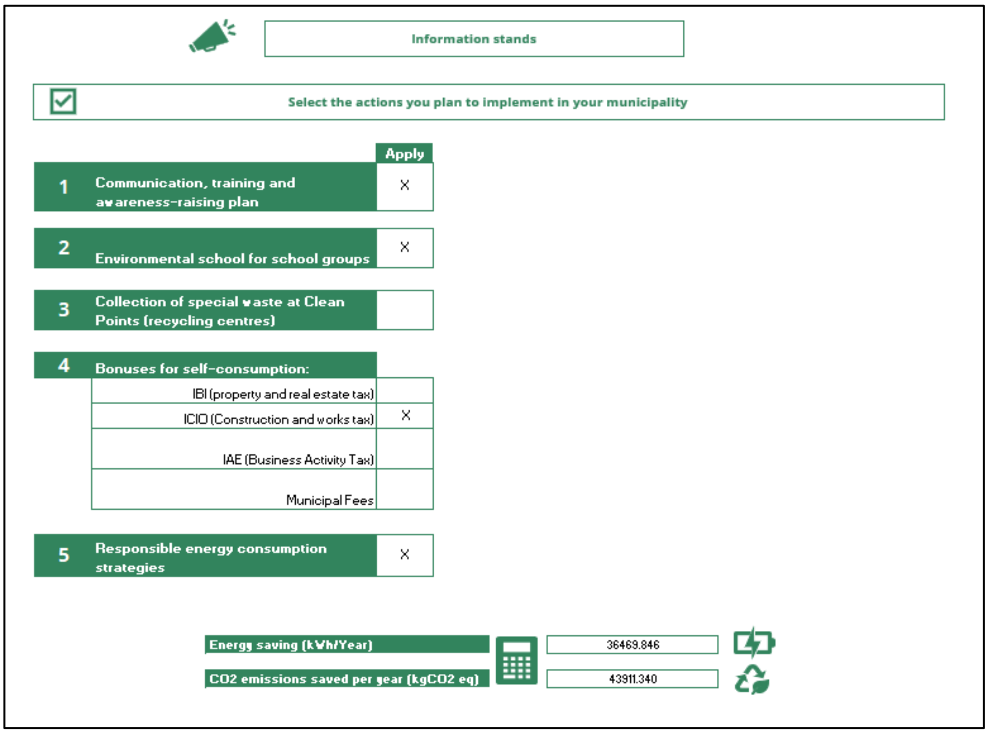
	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%	x	0.01
Increase in the frequency of PT passage	10%	x	0.00
Reducing fees for Youth and Pensioners	5%		0.00
Ecozone (ZBE)	97%		0.00
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the	20%		0.00
TOTAL			0.01

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	15.770

Figure 78. Measures to reduce traffic in Stintino

Awareness

Other measures include raising public awareness, creating communication and awareness plans, workshops for schools and energy consumption reduction strategies. In addition, discount rates for sustainable bioclimatic constructions are also proposed.



Information stands

Select the actions you plan to implement in your municipality

		Apply
1	Communication, training and awareness-raising plan	x
2	Environmental school for school groups	x
3	Collection of special waste at Clean Points (recycling centres)	
4	Bonuses for self-consumption:	
	IBI (property and real estate tax)	
	ICIO (Construction and works tax)	x
	IAE (Business Activity Tax)	
	Municipal Fees	
5	Responsible energy consumption strategies	x

Energy saving (kWh/Year)	36469.846
CO2 emissions saved per year (kgCO2 eq)	43911.340

Figure 79. Awareness measures implemented in Stintino

3.2.2.3. Multicriteria Decision in Stintino

Considering the priorities established by the municipality, the criteria used to prioritize the different levels are as follows:

- Adapt the municipality's public facilities, including the allocation of necessary resources.
- Involve civil society to develop and improve the action plan with citizen awareness.
- Reduce energy consumption through actions in municipal buildings, public lighting, redevelopment, traffic reduction and promotion of sustainable mobility.
- Inclusion of photovoltaic systems in buildings and land in the municipality, as well as promoting their installation at the individual level.
- Development of heating with cogeneration plants.
- Assistance to local companies to create new job opportunities related to energy efficiency.

The assessments are introduced in the chosen software applying the AHP method and a final report is obtained, suitable for the municipality of Stintino.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0146	0.0441	0.1219	8
	CA1.2 Improvement of municipal lighting	0.0190	0.0571	0.1578	6
	CA1.3 Heating, ventilation and air-conditioning systems	0.0268	0.0809	0.2234	4
	CA1.4 Introduction of renewable energies and self-consumption	0.1201	0.3622	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0085	0.0257	0.0711	11
	CA2.1 Industrial Process improvement	0.0044	0.0134	0.0370	14
	CA2.2 Renewal of industrial equipment	0.0060	0.0182	0.0501	12
	CA2.3 Improvement of Industrial buildings	0.0121	0.0366	0.1010	9
	CA2.4 Change of energy vector	0.0091	0.0273	0.0755	10
	CA3.1 Cycling Routes	0.0337	0.1015	0.2803	2
	CA3.2 Network of EV recharging points	0.0185	0.0556	0.1536	7
	CA3.3 Promoting public transport	0.0215	0.0649	0.1790	5
	CA4.1 Ecomovil	0.0055	0.0167	0.0460	13
	CA4.2 Information stands	0.0317	0.0956	0.2640	3

Figure 80. Report on alternatives obtained for the municipality of Stintino

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

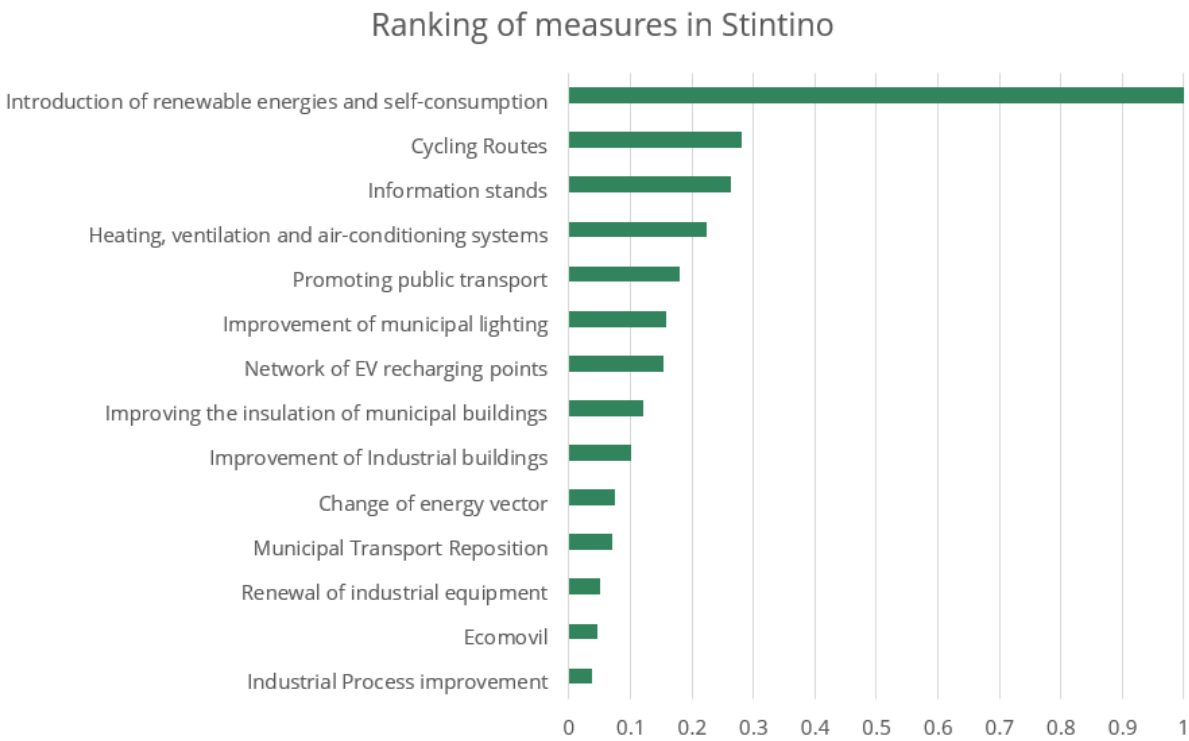


Figure 81. Ranking of most promising strategies for the municipality of Stintino

3.2.2.4. Ranking of the most promising strategies in Stintino

In summary, the most promising strategies for the municipality of Stintino are presented. A table with the results obtained by implementing the GENERA tools is presented below:

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
1	Introduction of renewable energies and self-consumption	277.77	124.12	Municipal facilities
2	Cycling Routes	-	26.80	Transport
3	Information stands	36.47	43.91	Awareness
4	Heating, ventilation and air-conditioning systems	15.52	6.94	Municipal facilities
5	Promoting public transport	-	0.015	Transport
6	Improvement of municipal lighting	27.60	12.33	Municipal facilities
7	Network of EV recharging points	-	366.55	Transport
8	Improving the insulation of municipal buildings	1.45	0.65	Municipal facilities
9	Improvement of Industrial buildings	1279.30	571.85	Industry
10	Change of energy vector	-	-	Industry

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
11	Municipal Transport Reposition	-	1.15	Municipal facilities
12	Renewal of industrial equipment	-	-	Industry
13	Ecomovil	-	-	Awareness
14	Industrial Process improvement	-	-	Industry
	TOTAL	**16019.74**	**1154.32**	

Table 7. Most promising strategies in Stintino and estimated associated energy and emissions reductions

Stintino focuses mainly on municipal measures but also puts special effort into awareness-raising measures in the field of energy saving and even the promotion of public transport. Even so, the industrial field remains outside the scope of the action plan, except for the improvement of industrial buildings where measures are implemented.

3.3. Greece

Greece in particular is characterized by the highest per capita electricity consumption and the highest external energy dependence, with the highest percentage of fuel imports, more than double the average of the 45 countries (8.3%). Compared to the other countries analyzed, Greece consumes the most renewable energy, however, there is also a higher use of coal. One of the future approaches for this group of countries could be the progressive reduction of per capita electricity consumption to converge towards more sustainable values [8].

3.3.1. Study of the Greek National Context

Greece aims to reduce its greenhouse gas emissions by 58% by 2030 and to reach net zero emissions by 2050. In addition, it is developing renewable energies, which should cover 81% of its capacity in 2030. Through the use of module 1 of the GENERA tool, an analysis of Greece's energy context is made. The reference data are taken from the year 2023, which is the year for which complete information is available. The Greek energy mix for energy supply is mainly characterized by oil (53.6%), followed by natural gas (20.9%). Renewable energies such as geothermal, wind and wind, biofuels and coal are the next contributions respectively. CO_2 emissions in Greece have been reduced by 42% compared to 2000 data, making Greece an emitter of 0.15% of global emissions.

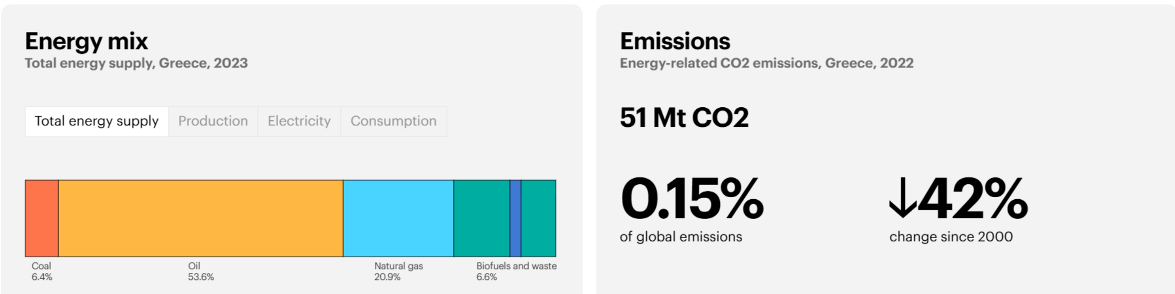


Figure 82. Summary of Greece's energy mix and emissions. Source: https://www.iea.org/countries/greece

Using Module 1 of the GENERA tools, 2022 reference data for Greece (as 2023 is incomplete for some sectors) are introduced and come from the International Energy Agency [1]. First, Figure 36 shows the contribution of each energy source in the main sectors of the economy. In Greece, there is a very high presence of oil in all sectors, although it stands out mainly in the transport sector, and others such as agriculture and fisheries. It is true that Greece requires maritime transport in most of its islands, so oil is necessary. Other sectors that also require oil are industrial, residential and electricity generation. The next most productive source is natural gas, which is most involved in electricity generation, followed by the industrial and residential sectors. Renewable energies are also producers of electricity and have a great impact on the residential sector. Finally, coal does not have a major impact in most sectors, except for electricity generation. It should be noted that there is no contribution from nuclear energy in Greece.

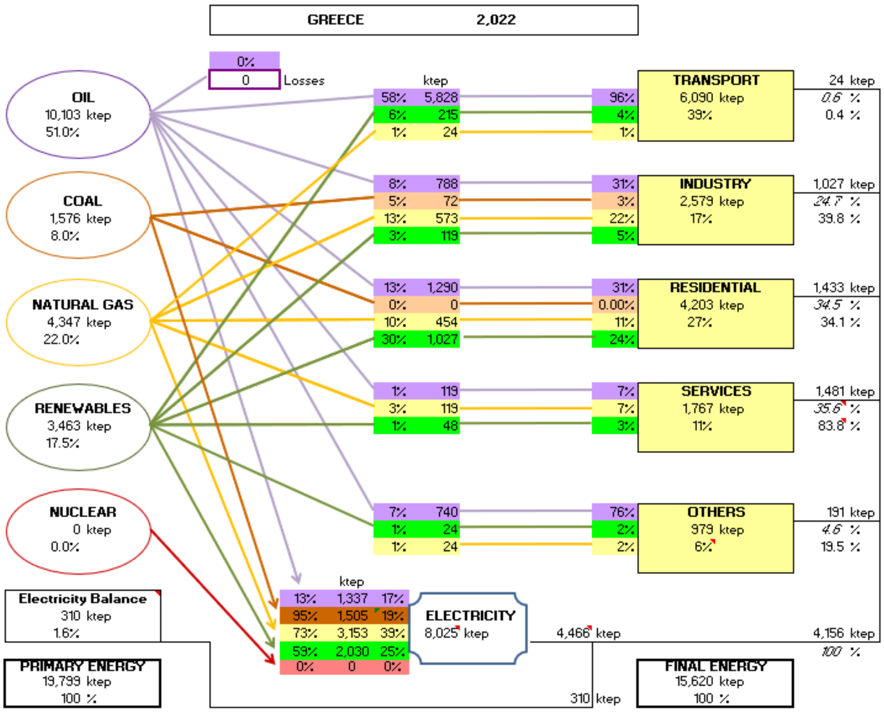


Figure 83. Energy balance of the different energy sources and sectors in Greece

After presenting an overview of the sources and sectors involved, the figures below show the evolution of the main indicators, such as primary energy demand, electricity generation and emissions up to 2030, following current trends.

First of all, the data on primary energy demand in the current Greek system show an increasing supply of oil. As discussed above, oil is the main source of energy, followed by natural gas. Therefore, Greece is heavily dependent on fossil fuels. However, renewable energies also have an increasing trend and are followed by natural gas. is very stable over the years, with the main share of natural gas and oil. In last place is coal, which has a very subtle growing tenure, so this could be reduced by implementing measures or encouraging the use of other types of energy.

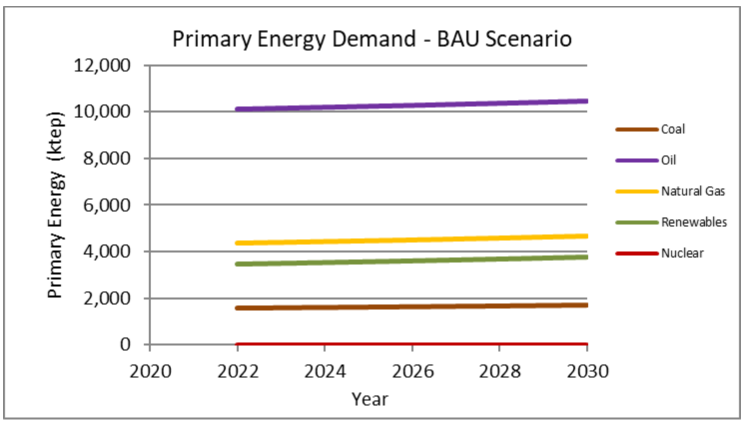


Figure 84. BAU Greece Scenario: Primary Energy Demand

Thereafter, electricity generation in Greece is mainly produced by Natural Gas, followed by renewable energies, coal and oil. All of them present an increasing trend. In addition, as mentioned above, there is no contribution from nuclear energy.

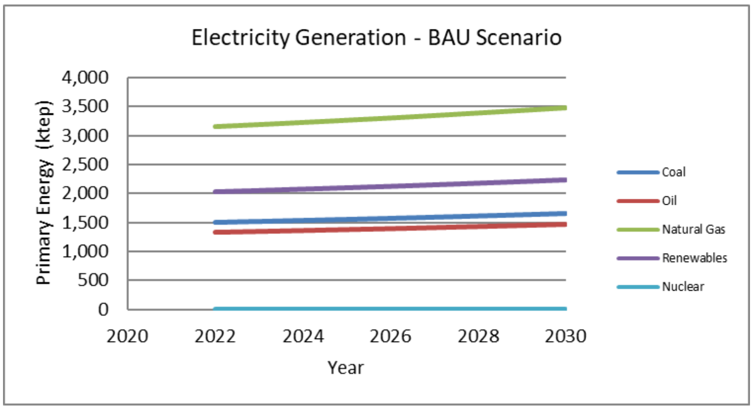


Figure 85. BAU Greece Scenario: Electricity Generation

Finally, Figure *86* shows the CO_2 emissions produced by each sector in Greece. The main CO_2 emitting sector is electricity generation, which may be due to the 19% contribution of coal (the sector in which coal is most involved), so implementing measures to reduce it is of vital importance. The transport sector continues with a lesser upward slope, which could be reduced by promoting public transport, low-emission zones, etc. The rest of the emissions are very evenly distributed among the residential, industrial and agriculture and fishing sectors. It should be noted that the industrial and agriculture and fishing sectors show a decreasing trend, so emissions are reduced.

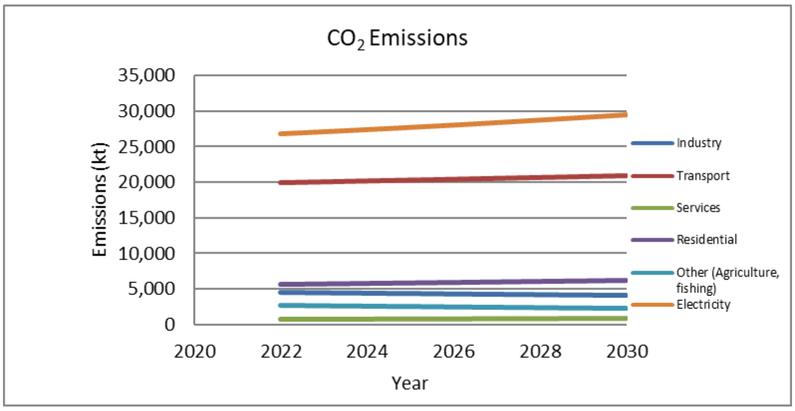


Figure 86. BAU Greece Scenario: CO_2 Emissions

The Greek energy context is mainly characterized by the use of oil and natural gas in sectors such as transportation and agriculture and fishing due to the country's economy. However, the sector that emits the most emissions is the electricity generation sector due mainly to coal. Renewable energies are more involved in the residential and electricity sectors. In addition, there is a growing trend in the use of renewable energies, mainly for electricity production. Natural gas also shows a growing trend and is among the main source of electricity generation. Finally, in terms of emissions, the most damaging sector is electricity generation, followed by transportation. Creating and implementing measures that encourage the use of renewable energies for electricity generation and for the transportation sector could be a goal to reduce emissions in the coming years.

3.3.2. Pilot 4 in Halki

3.3.2.1. Features of Halki

Halki is the smallest inhabited island of the Dodecanese with an area of 28 km2. It is part of the regional unit of Rhodes. It has a permanent population of 330 inhabitants (increasing during the summer months), concentrated only in the village. The 2021 census showed a population of 475 inhabitants [9]. The Dodecanese climate is a transitional type from temperate to dry tropical climates and is characterized by intense sunshine and prolonged summer drought.

It has a large photovoltaic park and is expected to install solar energy installations, so thanks to the relatively low consumption of the island, it is estimated that the island's energy needs can be covered.

Section	Objective
Renewable energy	It has a large photovoltaic park and is expected to install solar energy installations, so thanks to the relatively low consumption of the island, it is estimated that the island's energy needs can be covered.
CO_2 emissions	The municipality of Halki has set itself the target of reducing CO_2 by 105% by 2030, which exceeds the required 40% by far, so the emissions must be very demanding.

Table 8. Halki's main objectives in relation to energy sustainability

3.3.2.2. Summary of actions of Halki

The plan created for the Covenant of Mayors for Climate and Energy is studied for its creation and updating [10], and the measures are introduced in the GENERA tool for the evaluation of alternatives.

The main sectors in which the study is carried out are at the municipal, domestic and tertiary level, since industrial activity is almost nil in the municipality. At this stage, no measures are proposed for the introduction of renewable energies in municipal buildings, although the introduction of a solar energy park for solar energy production is proposed and will be considered in the tool.

Municipal Buildings And Public Facilities

- **Improving the building envelope**

Halki's plan also includes a section on buildings, equipment and facilities that includes actions such as improving the building's thermal insulation, as well as replacing windows with double glazing. In this case the actions are more generalized so an estimate is made in the GENERA tool.

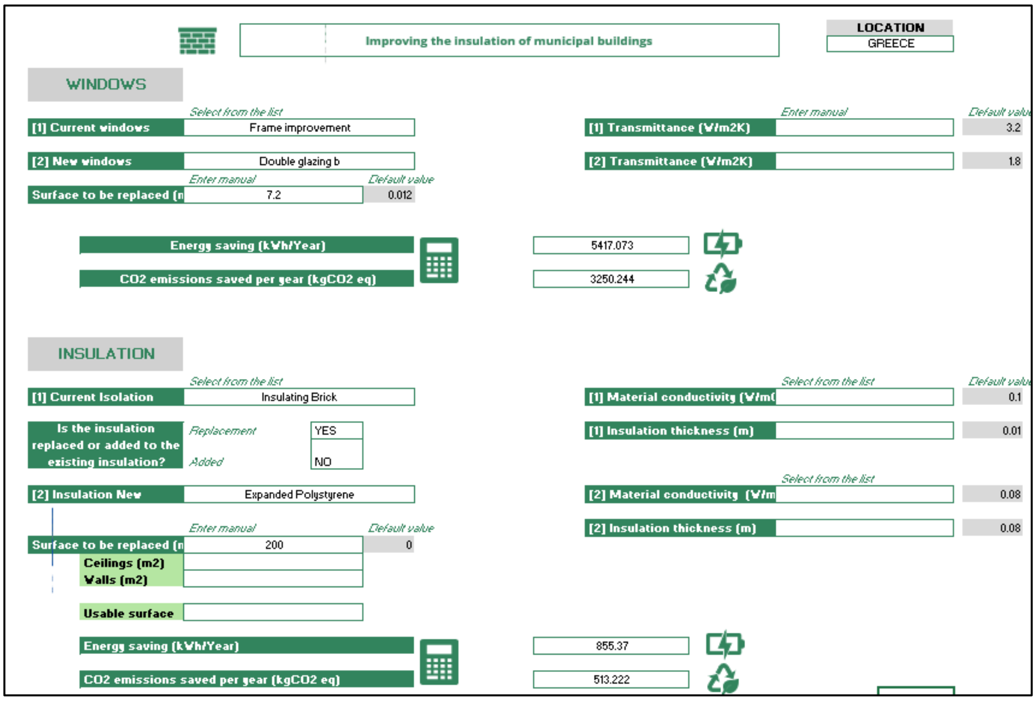


Figure 87. Improving the envelope of public buildings in Halki

- **Substitution Of Lights For More Efficient Ones**

The replacement of lighting fixtures is also another priority action; it is proposed to replace the current ones with more efficient LEDs. Therefore, in this point there are two measures: the first one related to the improvement of interior lighting in public buildings and, on the other hand, the improvement of municipal public lighting, which is intended to be modified by low consumption LEDs.

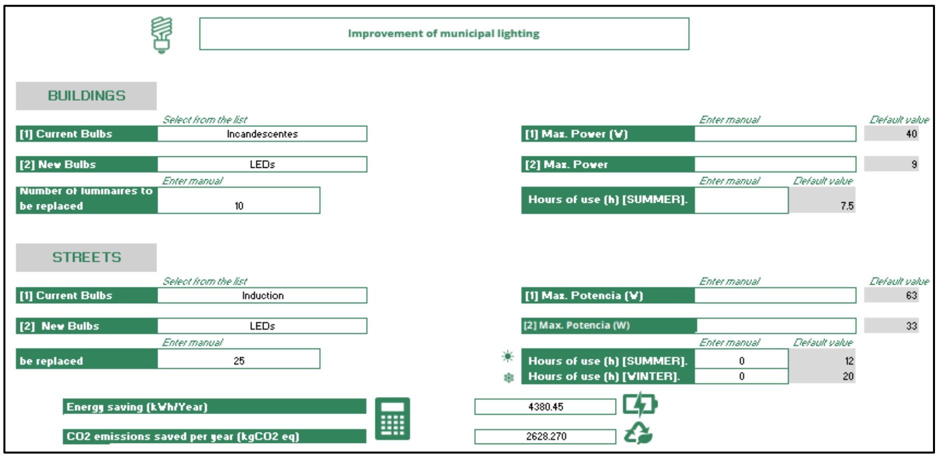


Figure 88. Lighting improvement measures at Halki

- **Improvement of building conditioning**

Improvements are proposed to the HVAC system, which currently consists of heat pump heating and cooling. The proposal is to improve the efficiency of the heat pump system, so a new one with better performance is proposed.

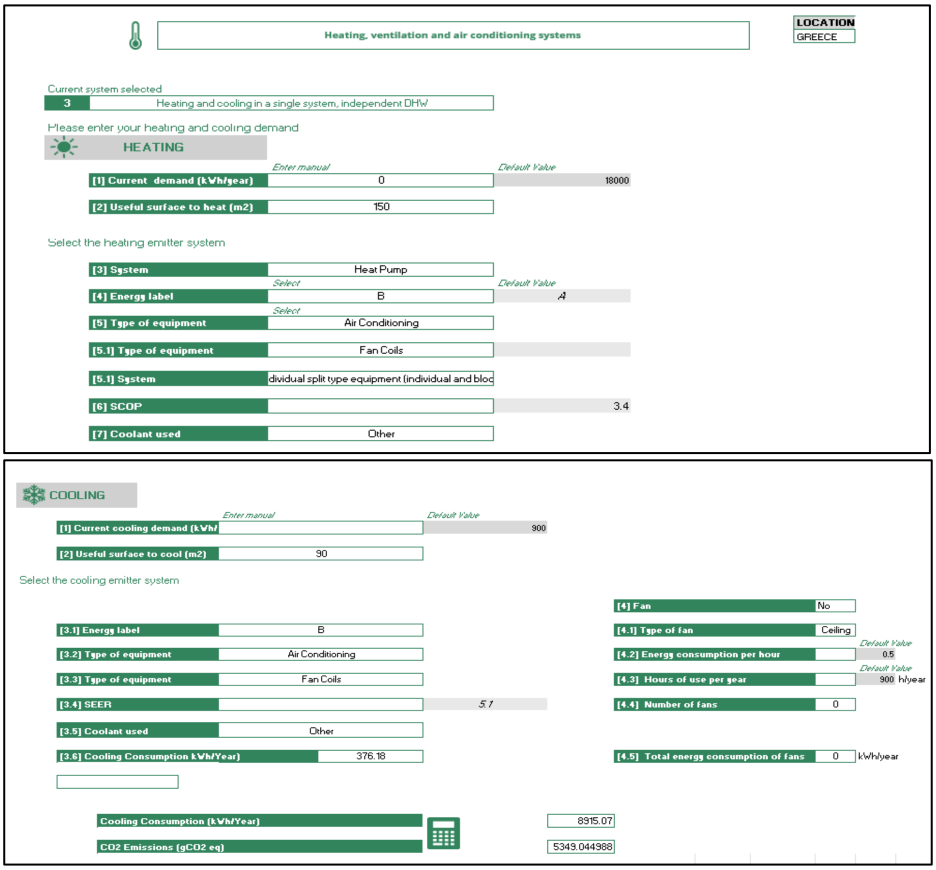


Figure 89. Consumption of the current heat pump system in Halki buildings

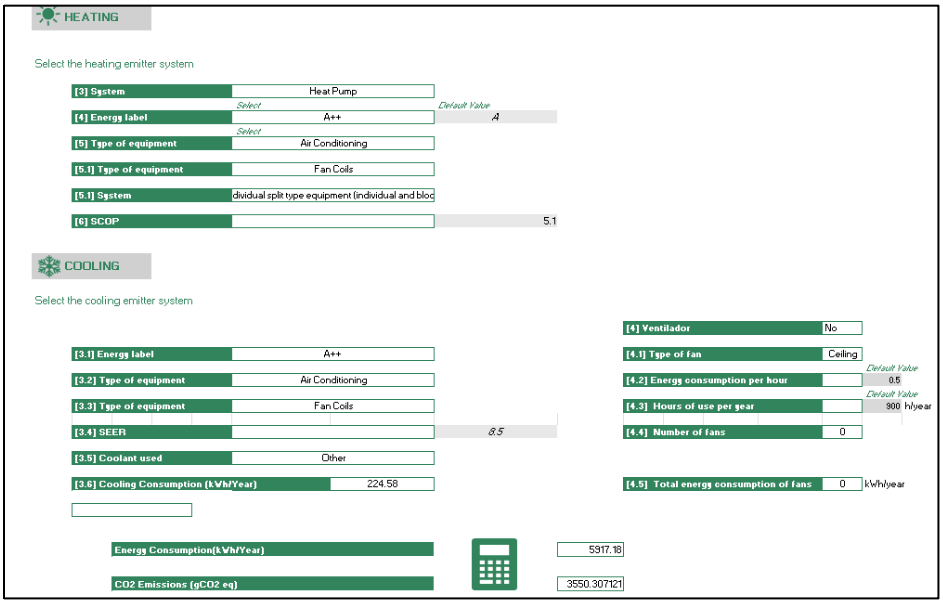


Figure 90. Renovation of the AACC system for municipalities in Halki

In summary, the energy saved and emissions mitigated by changing the air conditioning system is presented in the following figure:

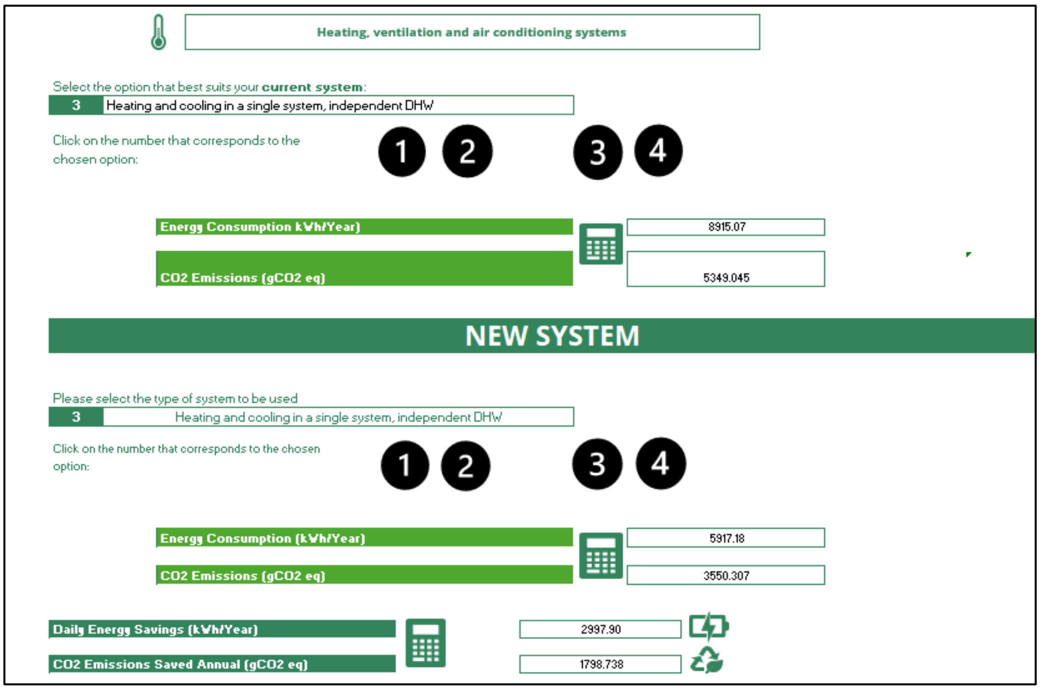


Figure 91. Summary of energy saved and emissions mitigated by the change of air conditioning in municipal buildings at Halki

- **Introduction of photovoltaic solar energy for power production**

Instead of proposing measures at the municipal level, it is proposed to introduce solar energy in a photovoltaic park with the idea of contributing to an energy community.

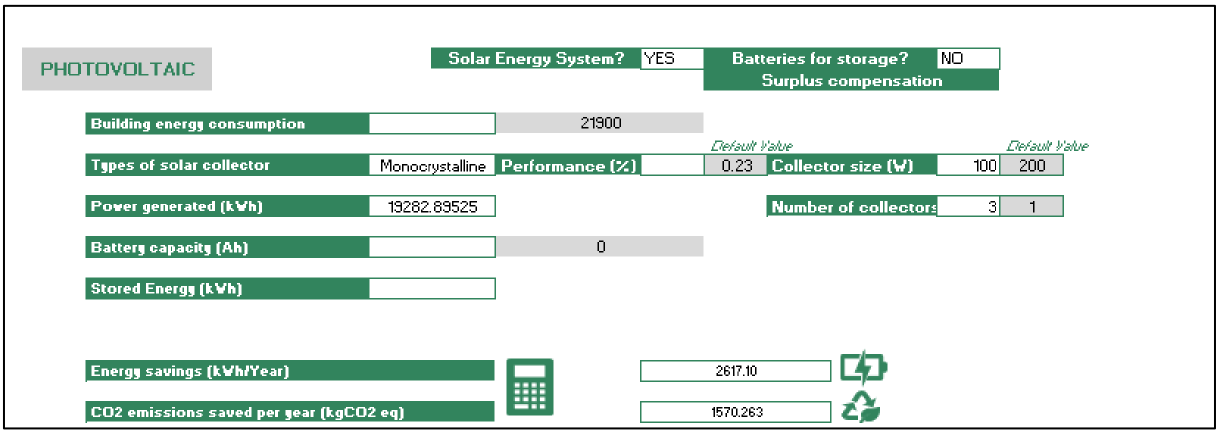


Figure 92. Photovoltaic solar energy in the municipality of Halki

- **Renewal of municipal fleet of energy efficient vehicles**

The municipality of Halki has replaced some vehicles in the municipal fleet with electric vehicles: 4 to cover municipal services and 2 more vehicles delivered to the police department.

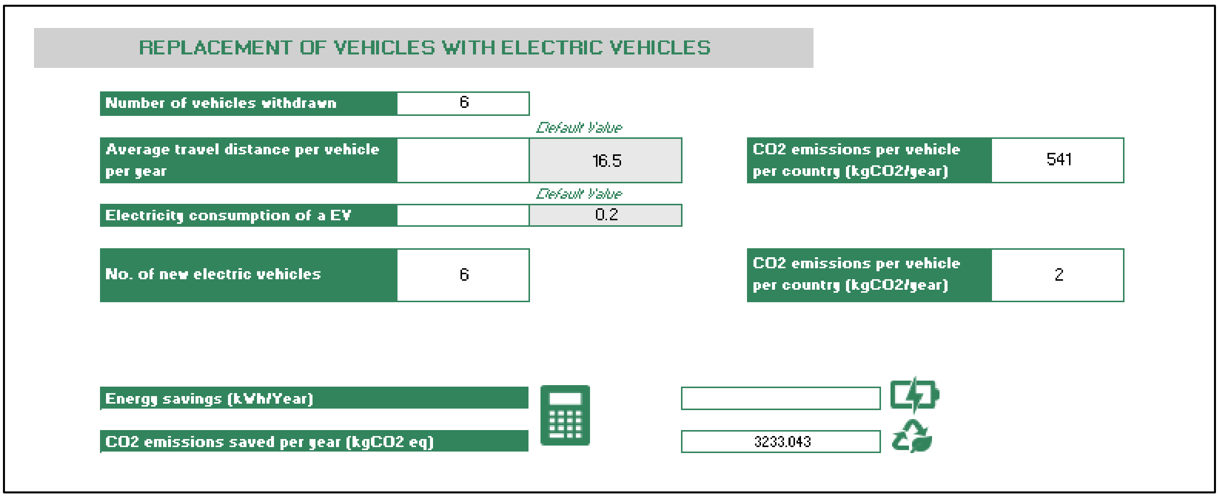


Figure 93. Emission reductions by replacing conventional vehicles with electric vehicles at Halki

Transport

Transport measures are other measures that may be of interest to the municipality to reduce its carbon footprint.

- **Cycling Routes**

A measure would be the introduction of cycling routes that encourage cycling and reduce the use of conventional vehicles.

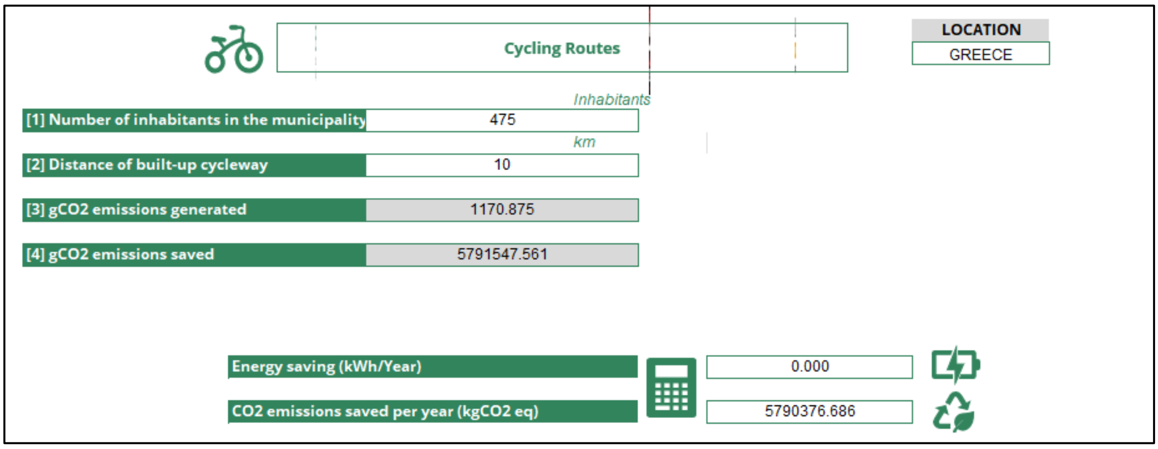
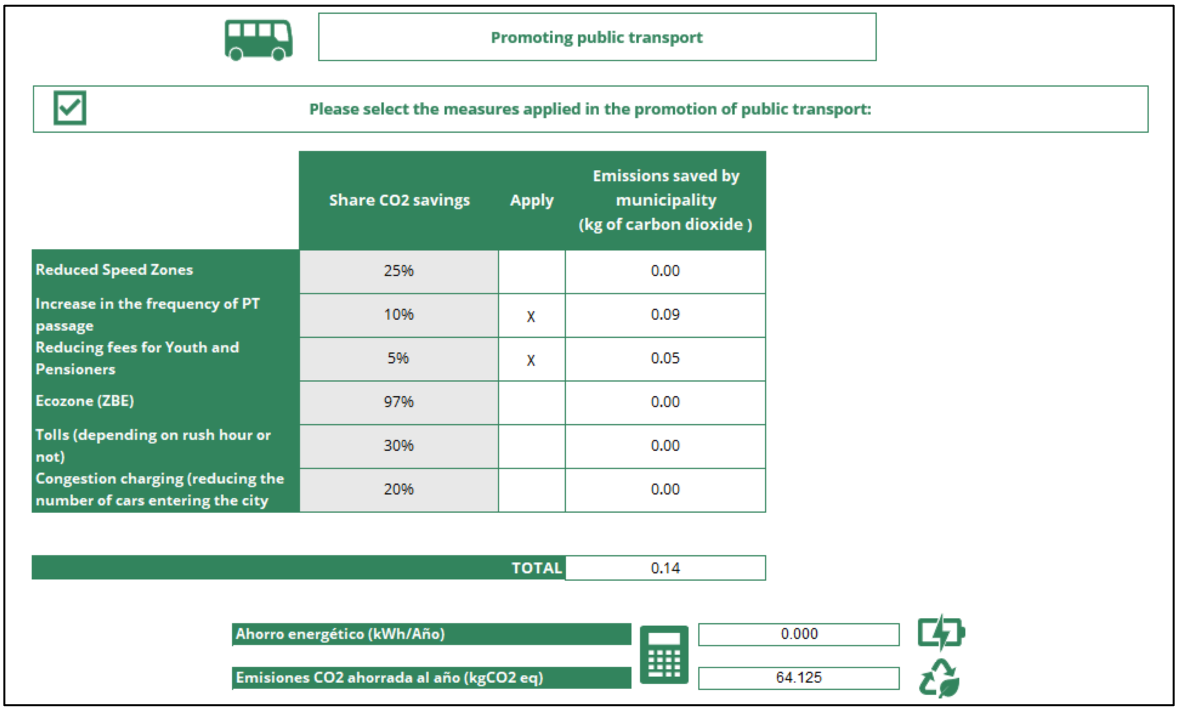


Figure 94. Creation of bike lanes in Halki

- **Promoting public transport**

The main measures introduced in relation to public transport are the improvement of the transport schedule and frequency, as well as the promotion of special fares for young people.



Promoting public transport

Please select the measures applied in the promotion of public transport:

	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%		0.00
Increase in the frequency of PT passage	10%	x	0.09
Reducing fees for Youth and Pensioners	5%	x	0.05
Ecozone (ZBE)	97%		0.00
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the city	20%		0.00
TOTAL			0.14

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	64.125

Figure 95. Measures to promote the use of public transport in Halki

Awareness

- **Implementation of Ecomovil**

The option of introducing an ecomovil to promote recycling and waste management is being considered.

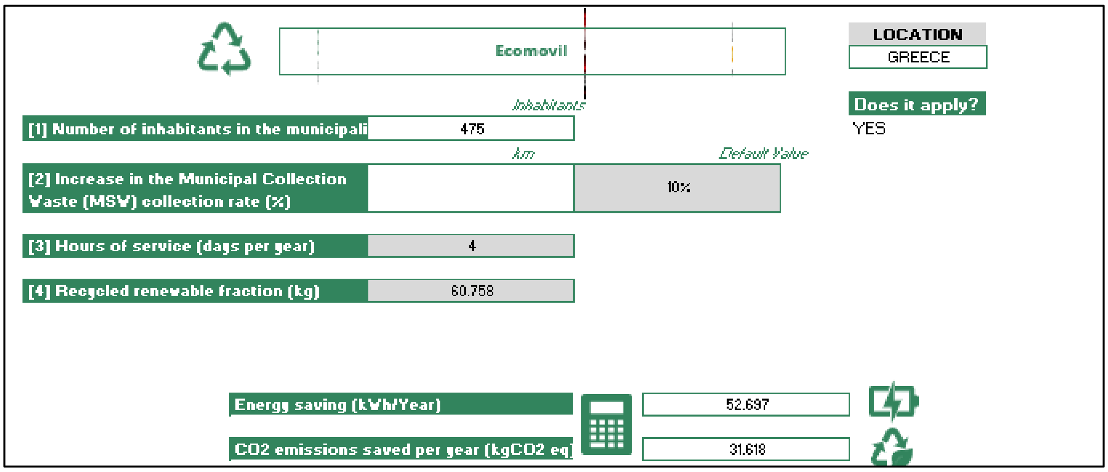


Figure 96. Recycling awareness action in Halki

- **Citizen promotion and awareness**

It is also proposed to work hard to raise public awareness. A communication and awareness-raising plan is proposed, including days for young people, training workshops, responsible consumption strategies for housing and tertiary sectors.

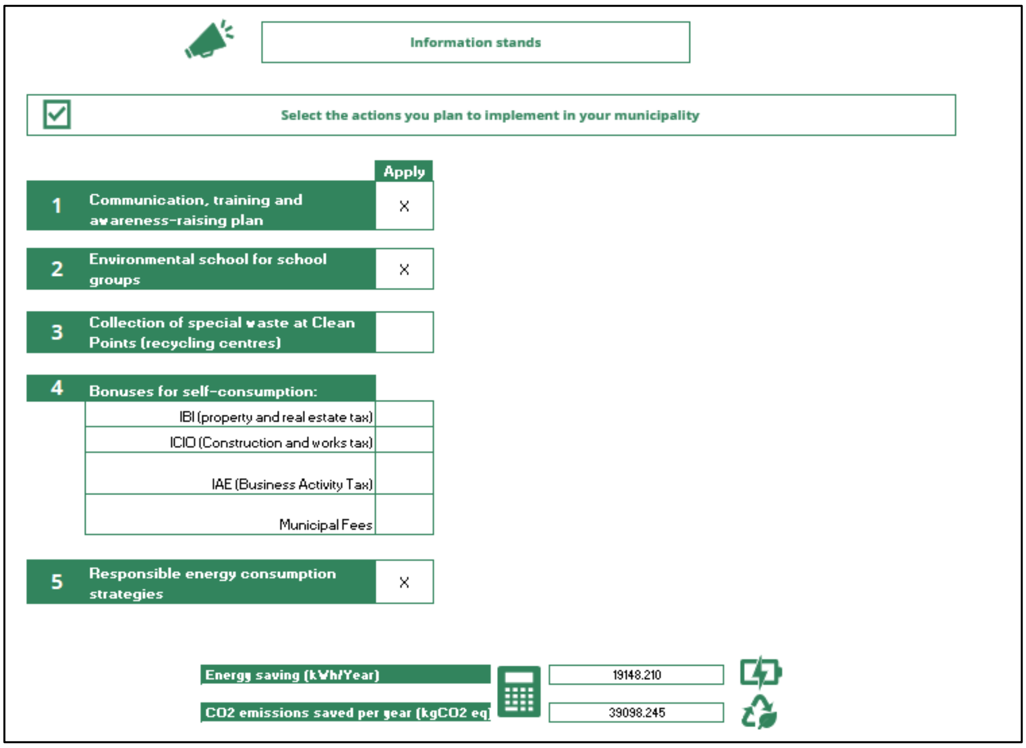


Figure 97. Sensitization actions for citizenship at the municipal level in Halki

3.3.2.3. Multicriteria Decision in Halki

Considering the priorities established by the municipality, priority actions are identified as follows:

- Promotion of recycling and organics reduction.
- Energy audit in municipal buildings.
- Information to users to improve the behaviour and optimal use of the different equipment.
- Substitution of LED lamps in lighting systems.
- Development of heating with cogeneration plants.
- Assistance to local companies to create new job opportunities related to energy efficiency.

The assessments are introduced in the chosen software applying the AHP method and a final report is obtained, suitable for the municipality of the municipality of Halki.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0108	0.0327	0.0940	8
	CA1.2 Improvement of municipal lighting	0.0172	0.0520	0.1494	6
	CA1.3 Heating, ventilation and air-conditioning systems	0.0310	0.0936	0.2690	3
	CA1.4 Introduction of renewable energies and self-consumption	0.1154	0.3479	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0078	0.0234	0.0674	10
	CA2.1 Industrial Process improvement	0.0040	0.0119	0.0343	14
	CA2.2 Renewal of industrial equipment	0.0048	0.0143	0.0412	13
	CA2.3 Improvement of Industrial buildings	0.0107	0.0323	0.0928	9
	CA2.4 Change of energy vector	0.0064	0.0192	0.0552	11
	CA3.1 Cycling Routes	0.0310	0.0935	0.2688	4
	CA3.2 Network of EV recharging points	0.0154	0.0464	0.1334	7
	CA3.3 Promoting public transport	0.0266	0.0801	0.2301	5
	CA4.1 Ecomovil	0.0053	0.0160	0.0461	12
	CA4.2 Information stands	0.0453	0.1366	0.3928	2

Figure 98. Report on alternatives obtained for the municipality of Halki

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

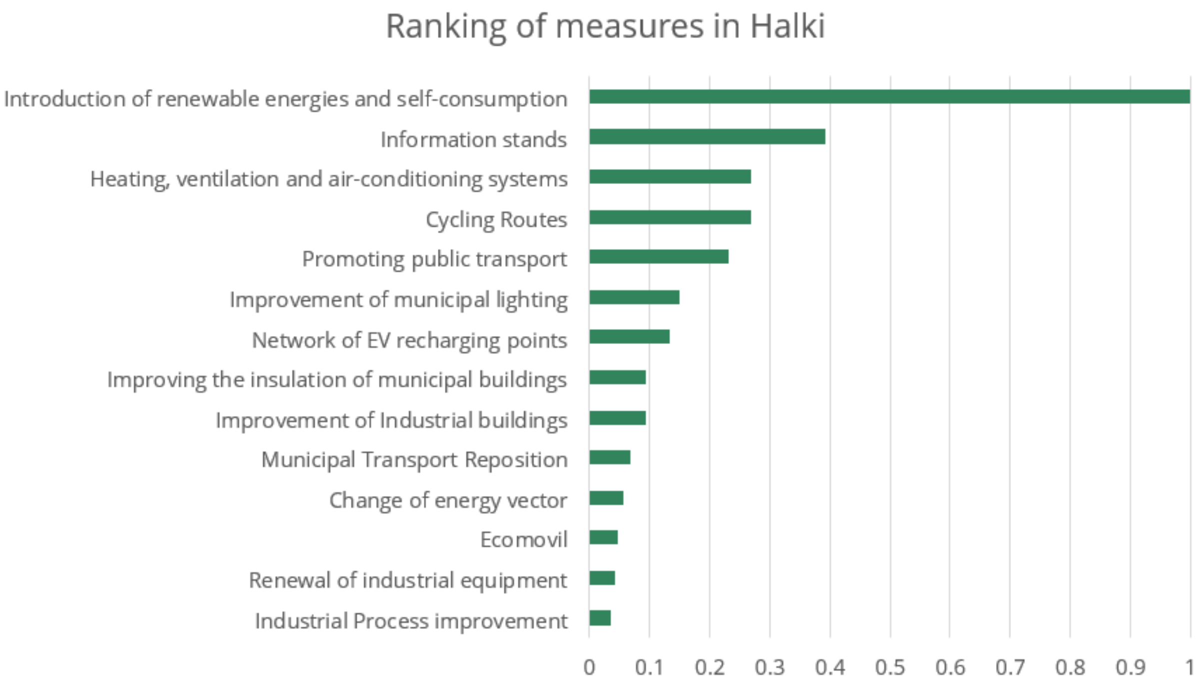


Figure 99. Ranking of most promising strategies for the municipality of Halki

3.3.2.4. Ranking of the most promising strategies in Halki

In summary, the most promising strategies for the municipality of Halki are presented. A table with the results obtained by implementing the GENERA tools is presented below:

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
1	Introduction of renewable energies and self-consumption	2.62	1.57	Municipal facilities
2	Information stands	0.33	0.68	Awareness
3	Heating, ventilation and air-conditioning systems	3.00	1.80	Municipal facilities
4	Cycling Routes	-	5.79	Transport
5	Promoting public transport	-	0.06	Transport
6	Improvement of municipal lighting	4.38	2.63	Municipal facilities
7	Network of EV recharging points	-	-	Transport
8	Improving the insulation of municipal buildings	6.27	3.76	Municipal facilities
9	Improvement of Industrial buildings	-	-	Industry

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
10	Municipal Transport Reposition	-	-	Industry
11	Change of energy vector	-	1.15	Municipal facilities
12	Ecomovil	0.053	0.031	Industry
13	Renewal of industrial equipment	-	-	Awareness
14	Industrial Process improvement	-	-	Industry
	TOTAL	**16.65**	**17.47**	

Table 9. Most promising strategies in Halki and estimated associated energy and emissions reductions

Halki is a very small municipality, so the reduction of energy and emissions is proportional to the number of inhabitants, although it is true that tourism modifies this number. As for the measures, the focus is on the municipal level and on raising public awareness, both in terms of sensitivity and the promotion of transportation.

3.3.3. Pilot 5 in Rhodes

3.3.3.1. Features of Rhodes

Rhodes is the largest of the Dodecanese islands, between the Aegean Sea and the coast of the Middle East. The municipality, also called Rhodes consists of 56,000 inhabitants [9]. In terms of climate, Rhodes is characterized by a warm Mediterranean climate in summer, with dry summers and mild, wet winters.

The main productive sector is the tertiary sector, while the primary sector is essential to the local economy. The primary sector includes mainly olive growing, viticulture, livestock, beekeeping, fishing and aquaculture. On the other hand, the tertiary sector is characterized by commerce, tourism, public and private services mainly.

The main problem of the municipality of Rhodes is the remarkable demographic growth, which is closely related to the constantly increasing tourist activity. This will mean a greater demand for energy and, therefore, a larger emissions footprint that must be mitigated with sustainability measures.

The Rhodes Municipality signed the Covenant of Mayors and committed itself to local action in the direction of sustainability in line with the objectives set by the EU by 2030:

Section	Objective

CO_2 emissions	Increase secure energy supply and reduce reliance on imported amounts of energy to reduce the island's energy footprint and greenhouse gas emissions by 40.18% from 2015 levels.

Table 10. Sustainable objectives to be achieved by the municipality of Rhodes

3.3.3.2. Summary of actions of Rhodes

The goals and objectives of the municipality of Rodes can be grouped into the following groups according to the information gathered from its action plan [11]: improvement of building efficiency, electrification of transport, energy improvement of public lighting, energy improvement of water supply and irrigation infrastructures and renewable energy sources to meet the needs of demand.

Municipal Buildings And Public Facilities

Rhodes proposes a large number of energy saving and efficiency measures, but directly aimed at consumers and citizens, for example: reduction of DHW demand with saving measures, improvement of heating and/or cooling measures with interventions in the building, etc. However, the GENERA tool will be used to introduce these measures, although they are not applied at the municipal level but rather at the local level.

- **Improving the building envelope**

One of the measures proposed is to increase energy efficiency in construction by replacing old systems, which is why it is proposed to introduce better insulation and windows.

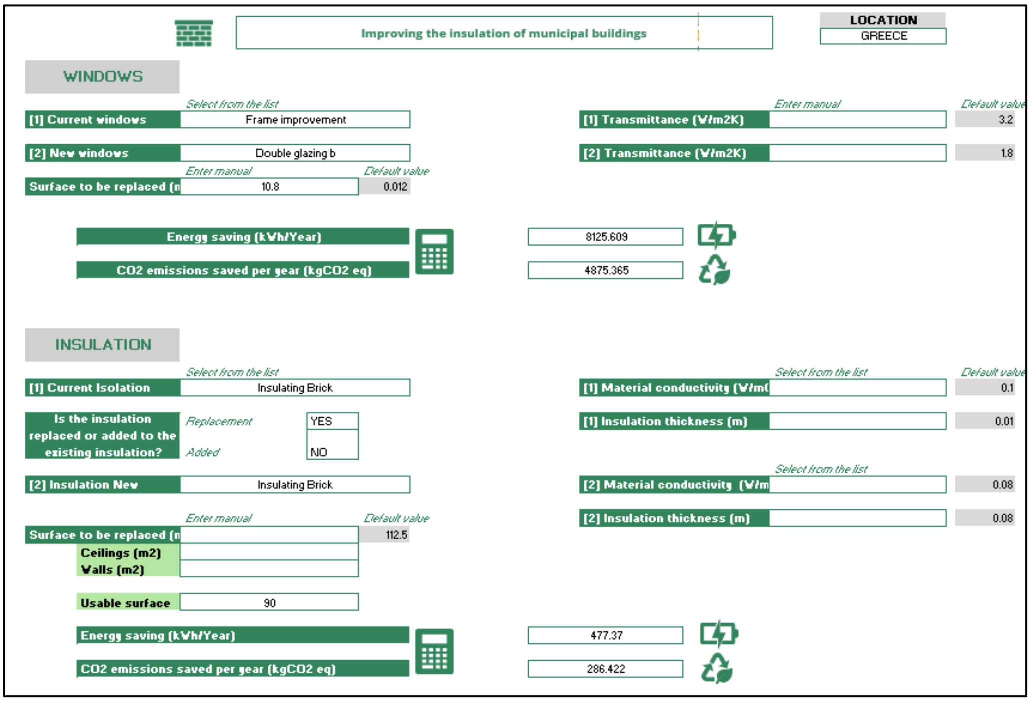


Figure 100. Construction efficiency measures in Rhodes.

- **Indoor lighting renovation**

The aim is to reduce lighting energy demand through the use of more efficient lighting systems, in addition to other awareness-raising measures.

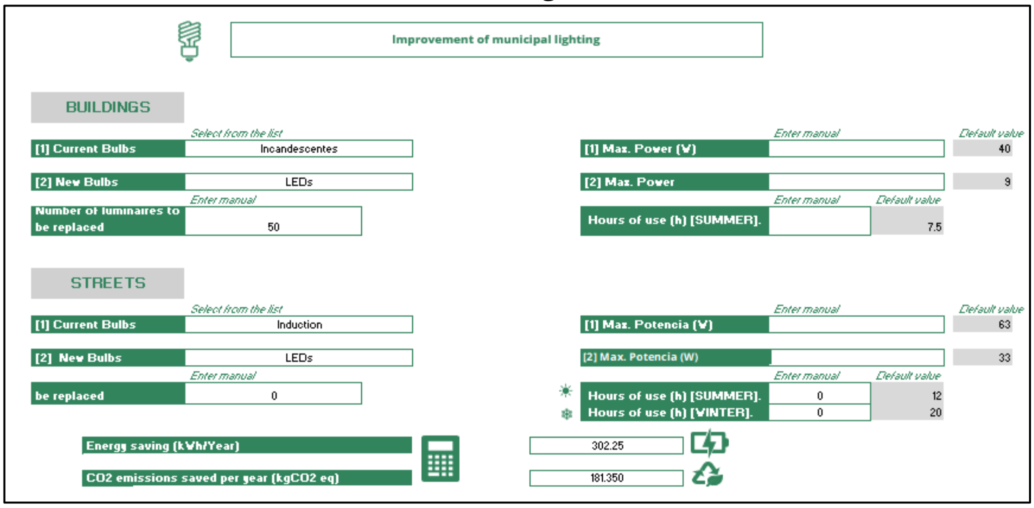


Figure 101. Improvement of lighting fixtures in buildings in Rhodes

- **Improvement of building conditioning**

Improving energy efficiency through the use of Class A inverter air conditioning systems is another measure being promoted at Rhodes.

Figure 102. Current air conditioning system in Rhodes

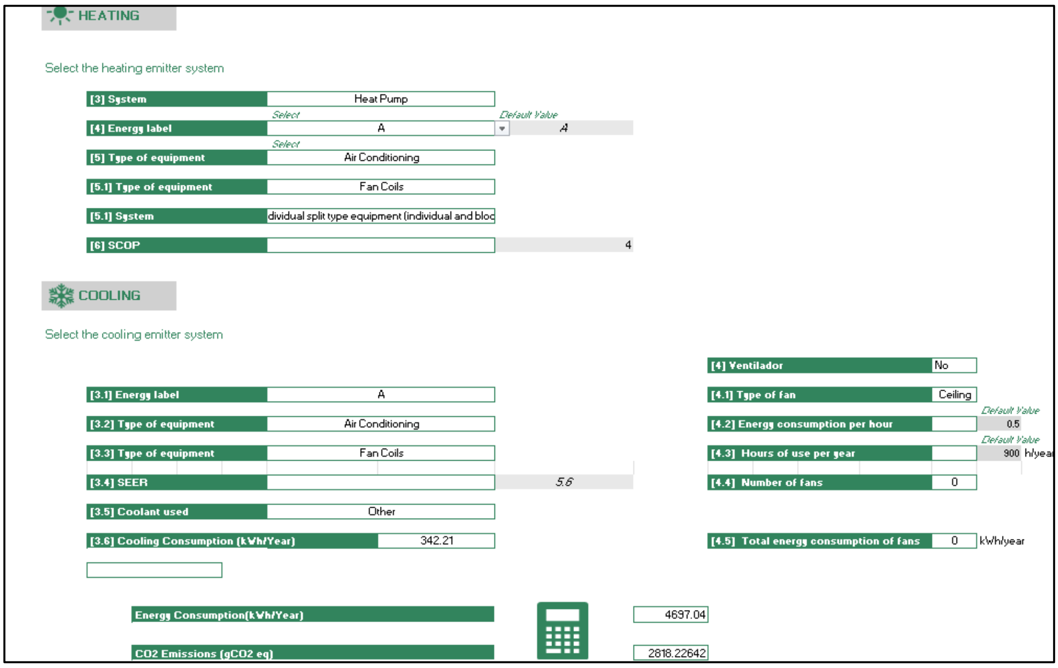


Figure 103. Improved air conditioning system in Rhodes

Improving the system with the aforementioned equipment results in a reduction of energy consumption and emissions as shown in the following figure:

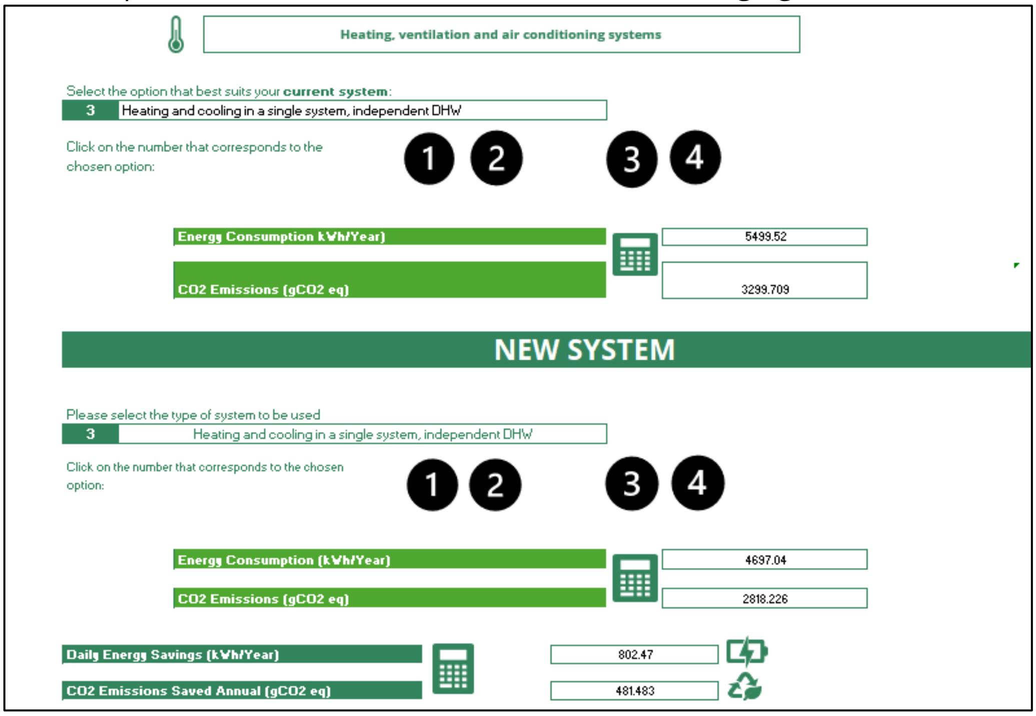


Figure 104. Energy savings and emissions mitigation by changing the air conditioning in Rhodes

- **Introduction of renewable energies in public buildings**

Reducing the annual rate of DHW energy demand through the use of solar thermal energy by 2030 is another of the municipality's priorities, but the use of this technology is encouraged at the individual level. However, it is also proposed for public buildings such as schools and other types, so the latter option is considered in the tool.

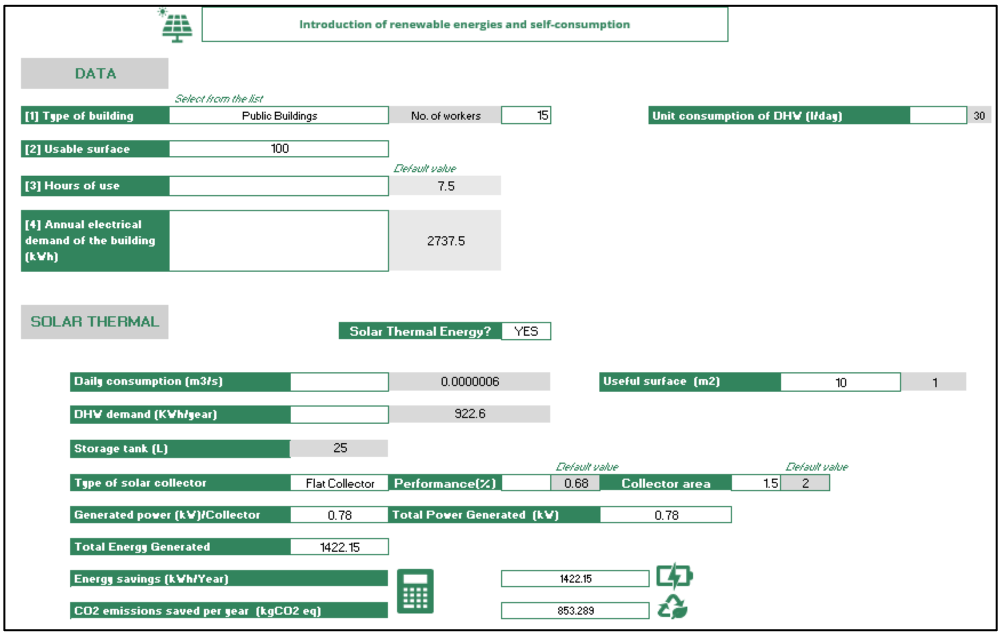


Figure 105. Implementation of solar thermal energy in buildings in Rhodes

It is also proposed to use agricultural waste biomass for electricity production, thus reducing energy costs and mitigating emissions.

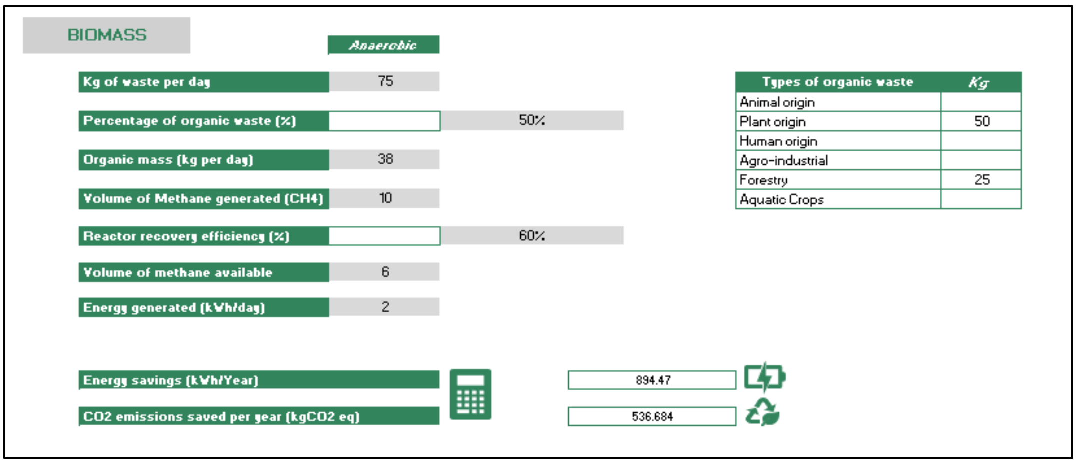


Figure 106. Use of biomass for energy use in Rhodes

- **Replacement of conventional municipal vehicles**

Replacing municipal vehicles with more efficient ones, such as electric vehicles, is another of the measures to be considered within the municipality. In this case, it is proposed to replace 3 vehicles by EV.

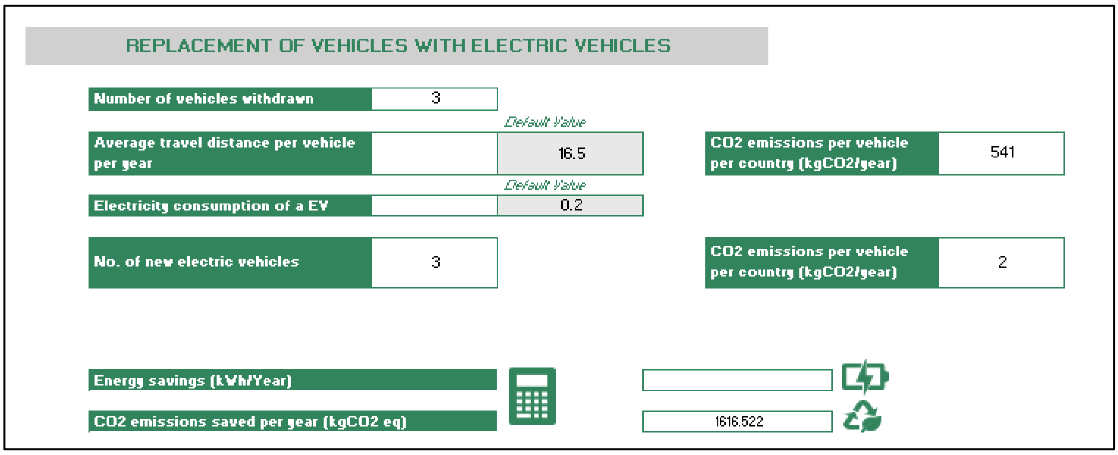


Figure 107. Replacement of conventional municipal vehicles in Rhodes

Industry

In the industrial field, measures are proposed for energy saving by consumers through the replacement of systems with more efficient ones.

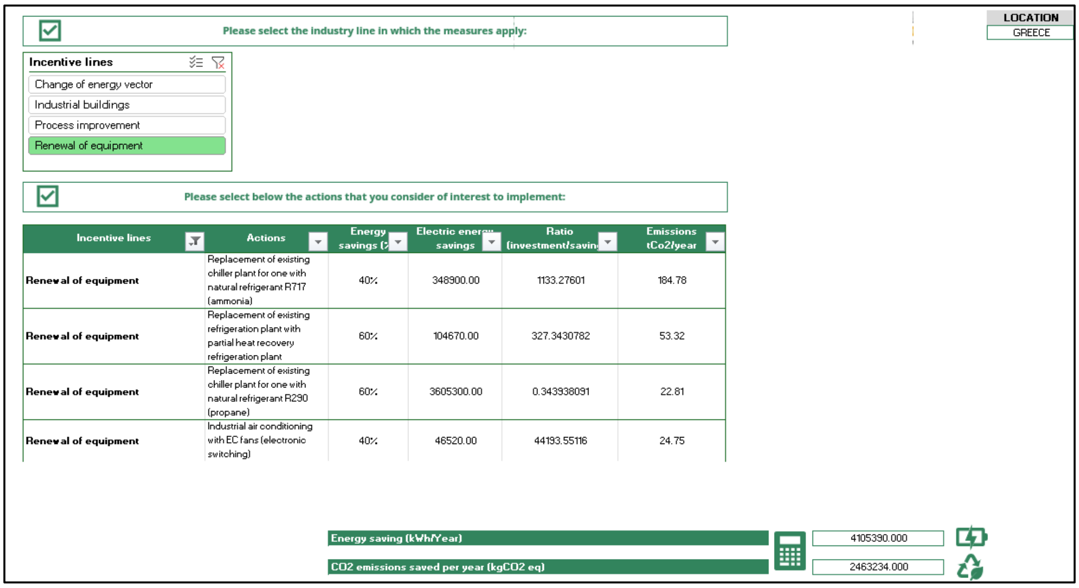


Figure 108. Rhodes industrial equipment refurbishment improvement measures

Transport

- **Construction of cycling lanes**

Rhodes has planned several important transportation measures, including the creation of bike lanes. Therefore, taking into account the inhabitants of the municipality and the distance, a 10 km bike path is proposed.

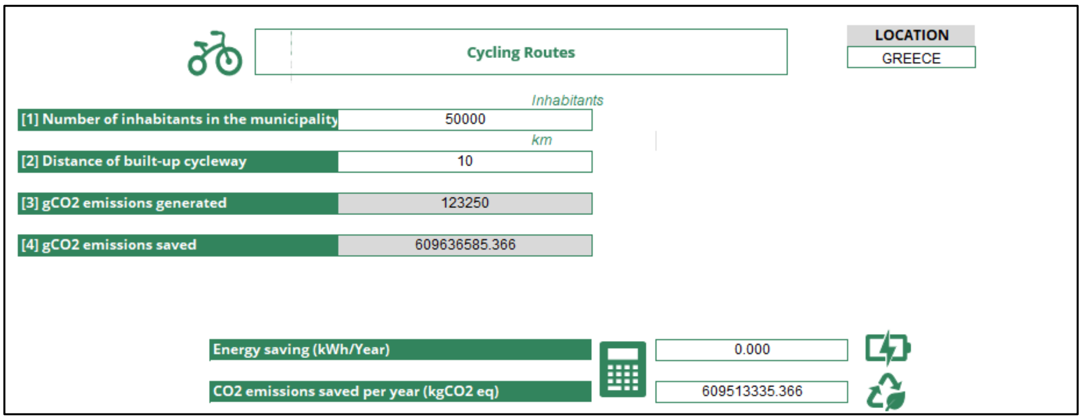


Figure 109. Creation of bike lanes in Rhodes

- **Charging points for hybrid or electric vehicles**

The use of electric vehicles and the implementation of charging points is another measure that promotes the reduction of emissions at the municipal level. This measure is in line with the replacement of EVs at the municipal level. Due to the size of the municipality, it is proposed to introduce 2 EV charging points.

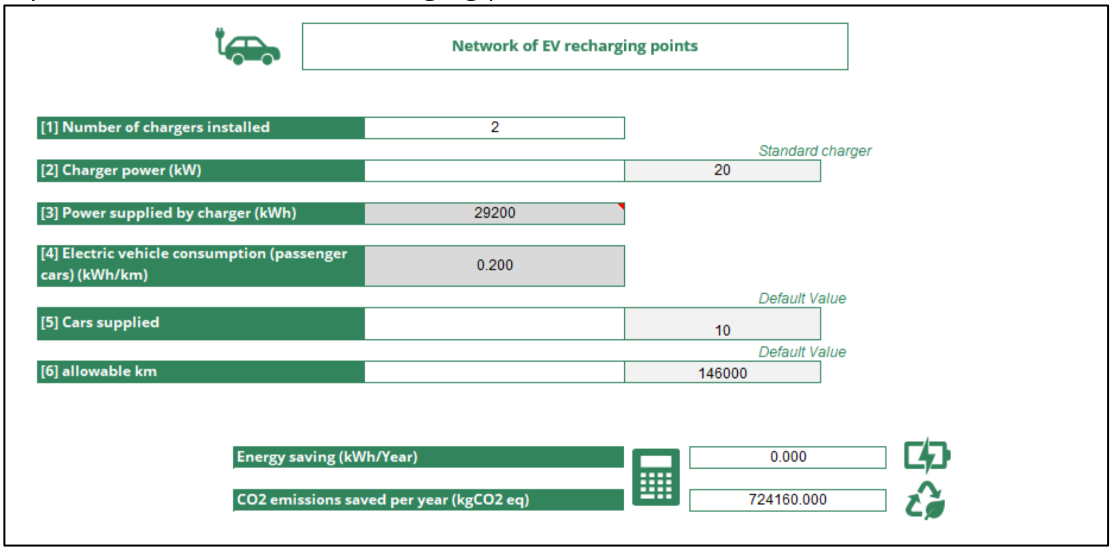


Figure 110. Creation of EV recharging points in Rhodes

- **Promotion of public transport**

The last measure is the promotion of public transport among the citizens, mainly by increasing the frequency of public transport and the reduction of fees for young people and pensioners.

Promoting public transport

Please select the measures applied in the promotion of public transport:

	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%		0.00
Increase in the frequency of PT passage	10%	x	0.09
Reducing fees for Youth and Pensioners	5%	x	0.05
Ecozone (ZBE)	97%		0.00
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the city	20%		0.00
TOTAL			0.14

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	0.135

Figure 111. Promotion of public transport in Rhodes

Awareness

A large number of energy saving and consumption reduction measures are proposed for citizens.

- **Citizen promotion and awareness**

Many measures proposed in Rhodes are aimed at citizens with the idea of promoting energy saving measures and introducing new, more efficient systems.

Information stands

Select the actions you plan to implement in your municipality

		Apply
1	Communication, training and awareness-raising plan	X
2	Environmental school for school groups	X
3	Collection of special waste at Clean Points (recycling centres)	
4	Bonuses for self-consumption:	
	IBI (property and real estate tax)	
	ICIO (Construction and works tax)	X
	IAE (Business Activity Tax)	
	Municipal Fees	
5	Responsible energy consumption strategies	X

Energy saving (kWh/Year)	40242.876
CO2 emissions saved per year (kgCO2 eq	51755.045

Figure 112. Public awareness measures in Rhodes

3.3.3.3. Multicriteria Decision in Rhodes

Considering the priorities established by the municipality, the criteria used to prioritize the different levels are as follows:

- At the municipal level, energy saving and efficiency measures are implemented.
- Electricity production from renewable sources is a priority, to minimize fossil fuels and encourage local generation.
- In the tertiary sector, equipment renovation is also promoted.

The assessments are introduced in the chosen software applying the AHP method and a final report is obtained, suitable for the municipality of Rhodes.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0107	0.0323	0.0893	8
	CA1.2 Improvement of municipal lighting	0.0172	0.0519	0.1434	6
	CA1.3 Heating, ventilation and air-conditioning systems	0.0300	0.0903	0.2498	4
	CA1.4 Introduction of renewable energies and self-consumption	0.1199	0.3616	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0078	0.0234	0.0648	10
	CA2.1 Industrial Process improvement	0.0045	0.0134	0.0371	14
	CA2.2 Renewal of industrial equipment	0.0054	0.0163	0.0450	12
	CA2.3 Improvement of Industrial buildings	0.0103	0.0309	0.0855	9
	CA2.4 Change of energy vector	0.0065	0.0195	0.0539	11
	CA3.1 Cycling Routes	0.0311	0.0937	0.2591	3
	CA3.2 Network of EV recharging points	0.0167	0.0503	0.1391	7
	CA3.3 Promoting public transport	0.0266	0.0801	0.2214	5
	CA4.1 Ecomovil	0.0052	0.0156	0.0430	13
	CA4.2 Information stands	0.0400	0.1207	0.3338	2

Figure 113. Report on alternatives obtained for the municipality of Rhodes

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

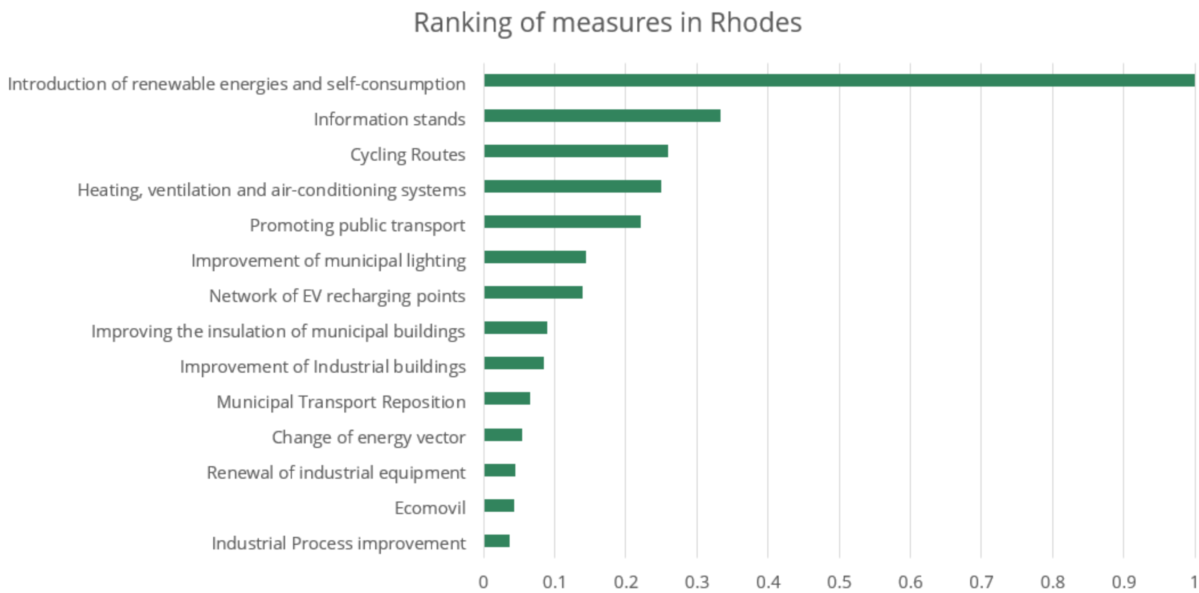


Figure 114. Ranking of most promising strategies for the municipality of Rhodes

3.3.3.4. Ranking of the most promising strategies in Rhodes

In summary, the most promising strategies for the municipality of Rhodes are presented. A table with the results obtained by implementing the GENERA tools is presented below:

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
1	Introduction of renewable energies and self-consumption	2.32	1.39	Municipal facilities
2	Information stands	73.35	94.34	Awareness
3	Cycling Routes	-	609.51	Transport
4	Heating, ventilation and air-conditioning systems	0.80	0.48	Municipal facilities
5	Promoting public transport	-	6.75	Transport
6	Improvement of municipal lighting	0.30	0.18	Municipal facilities
7	Network of EV recharging points	-	724.16	Transport
8	Improving the insulation of municipal buildings	1.45	0.65	Municipal facilities
9	Improvement of Industrial buildings	8.60	5.16	Industry
10	Municipal Transport Reposition	-	1.61	Transport
11	Change of energy vector	-	-	Industry
12	Renewal of industrial equipment	4105.39	2463.23	Industry
13	Ecomovil	-	-	Awareness
14	Industrial Process improvement	-	-	Industry
	TOTAL	**4192.21**	**3907.46**	

Table 11. Most promising strategies in Rhodes and estimated associated energy and emissions reductions

The most promising strategies for Rhodes focus primarily on improving municipal facilities, public awareness and transportation. In addition, although not among their priorities, they also see the need for changes in industrial equipment to support the renovation of the tertiary sector and the reduction of municipal energy consumption.

3.3.4. Pilot 5 in Nisyros

3.3.4.1. Features of Nisyros

Nisyros is located in the southeastern Aegean Sea right in the center of the Dodecanese. It has a total area of 50,055 km2 and a total population of 1,048 inhabitants (2021) [9]. Nisyros has one of the largest geothermal deposits in Greece (second only to Milos), with an electricity generation potential of several tens of MW. The high amounts of (thermal) energy that can be extracted from shallow wells can cover the heating or energy supply needs of farms. Among the main objectives of the municipality to achieve in its plan through the actions highlights:

Section	Objective
Renewable Energy	Increasing the share of renewable energies in the energy balance and, above all, exploiting the island's remarkable geothermal field.
CO_2 emissions	The City Council aims for a 100% reduction in local emissions.
Energy Efficiency	To reduce the economic consumption of energy in urban infrastructure and municipal lighting, by improving the energy efficiency of the equipment.
Energy Savings	Reduce energy consumption in the construction sector, with the promotion of energy saving actions in hotels and municipal buildings and with actions to inform residents, as regards the domestic sector.

Table 12. Objectives of the energy plan for the municipality of Nisyros

3.3.4.2. Summary of actions of Nisyros

Among the main actions that have been observed in its plan [12] are the categories of municipal equipment and infrastructure, along with lighting, transportation and awareness-raising measures.

Municipal Buildings And Public Facilities

- **Renewal of lighting fixtures**

Nisyros proposes lighting improvement measures at the municipal level. Therefore, the changeover to LED luminaires for both indoor and outdoor street lighting is proposed.

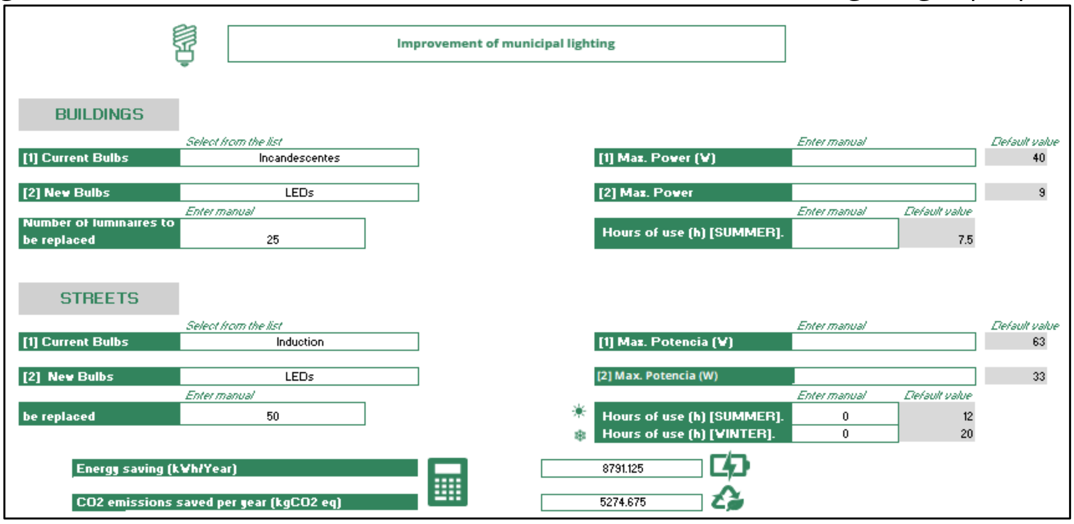


Figure 115. Installation of more efficient luminaires in Nisyros

- **Improvement of building conditioning**

Air conditioning on the Greek islands is necessary, mainly in summer. Nisyros is committed to the use of geothermal energy for local power generation and also for use in air conditioning. Therefore, it is proposed to switch from heat pumps with lower energy labelling to the use of geothermal energy for heating, cooling and DHW.

On the one hand, the data of the previous system are entered into the tool, considering a heat pump for heating and cooling, and an oil boiler for DHW.

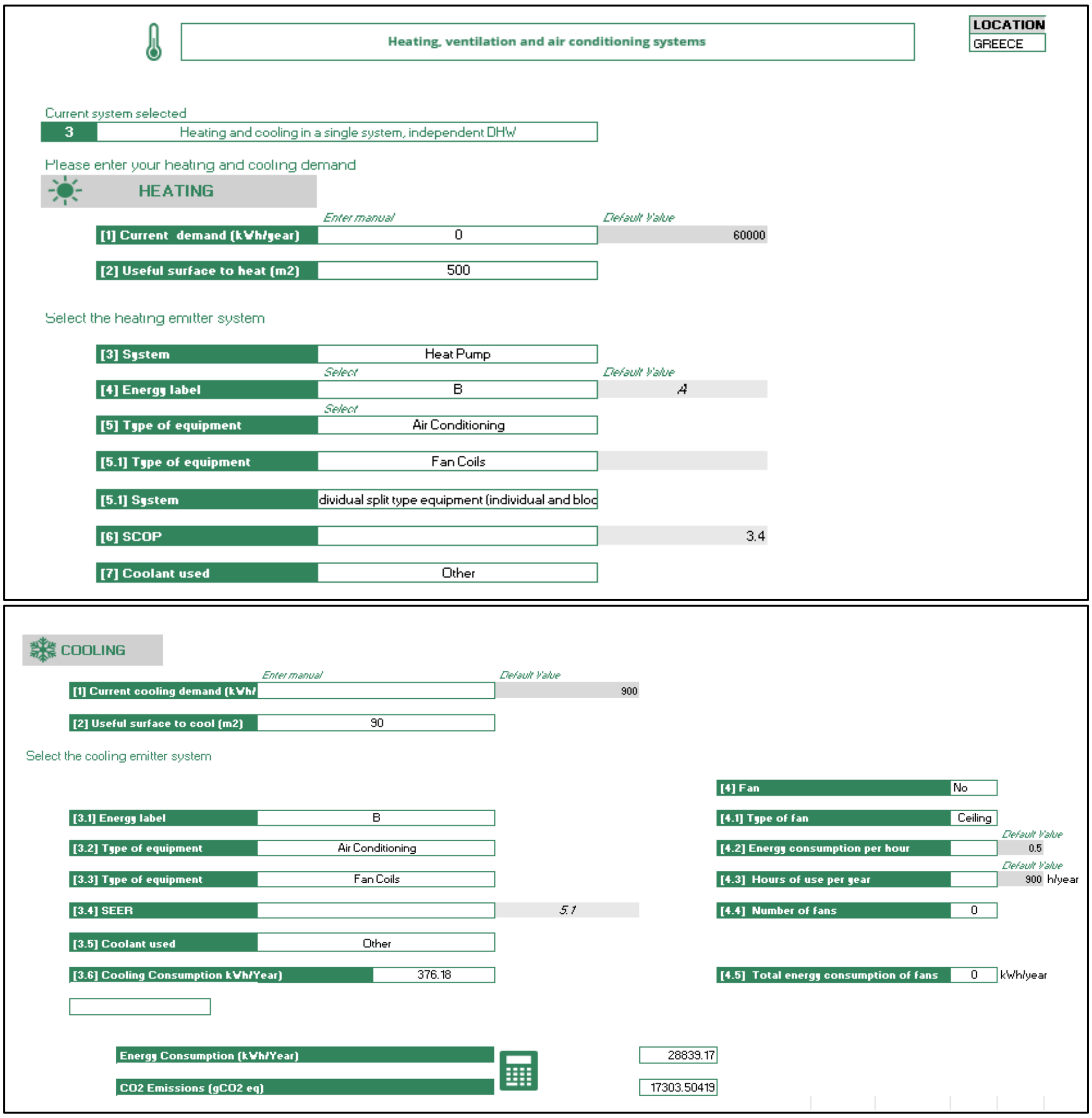


Figure 116. Heat pump system for heating and cooling in Nisyros

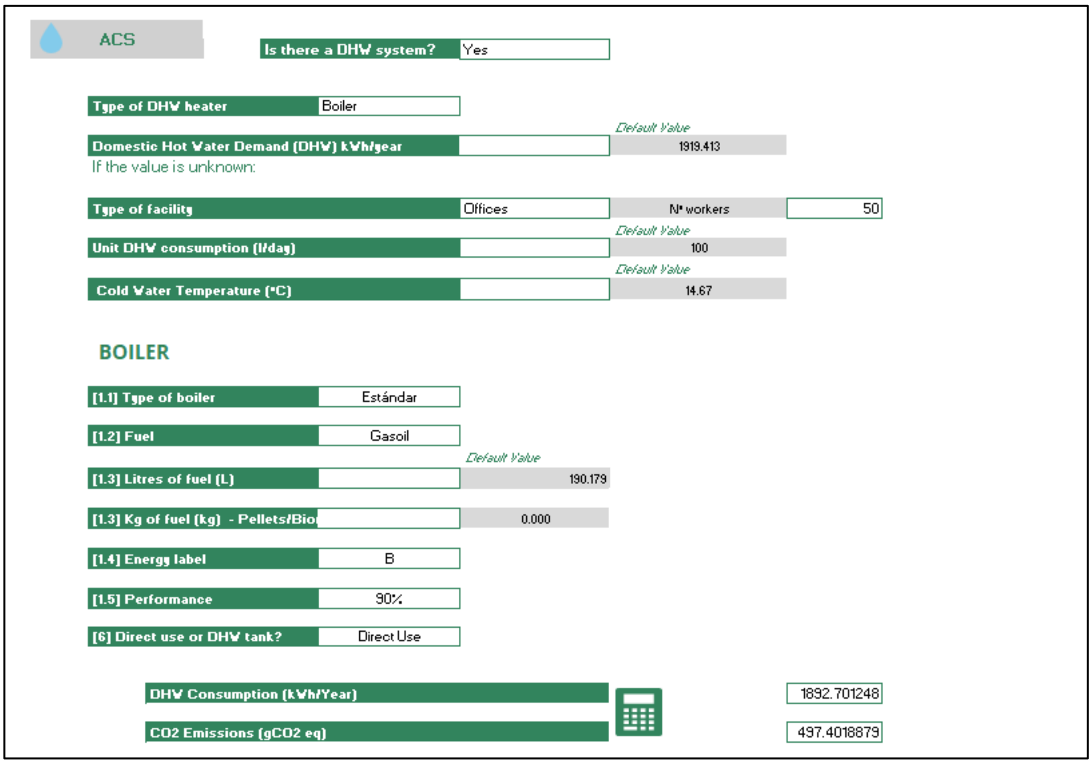


Figure 117. Preliminary DHW system at Nisyros

Afterwards, the new heat pump data is introduced, but using geothermal energy.

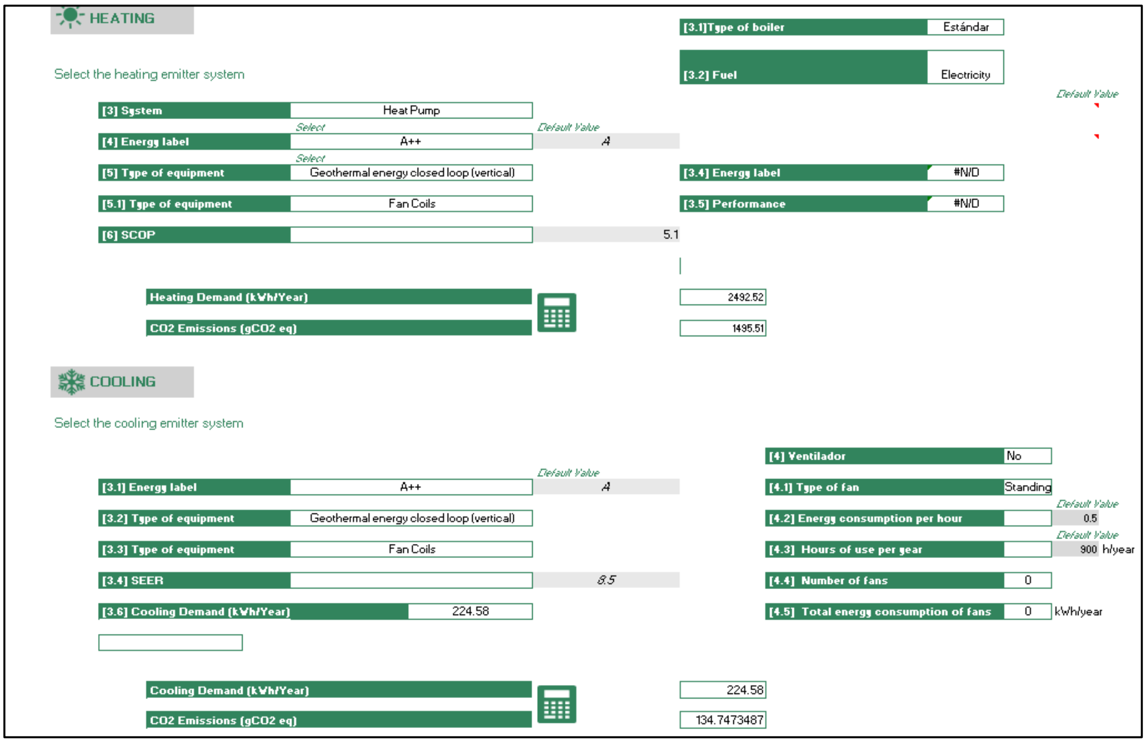


Figure 118. New heating, cooling and DHW system in Nisyros

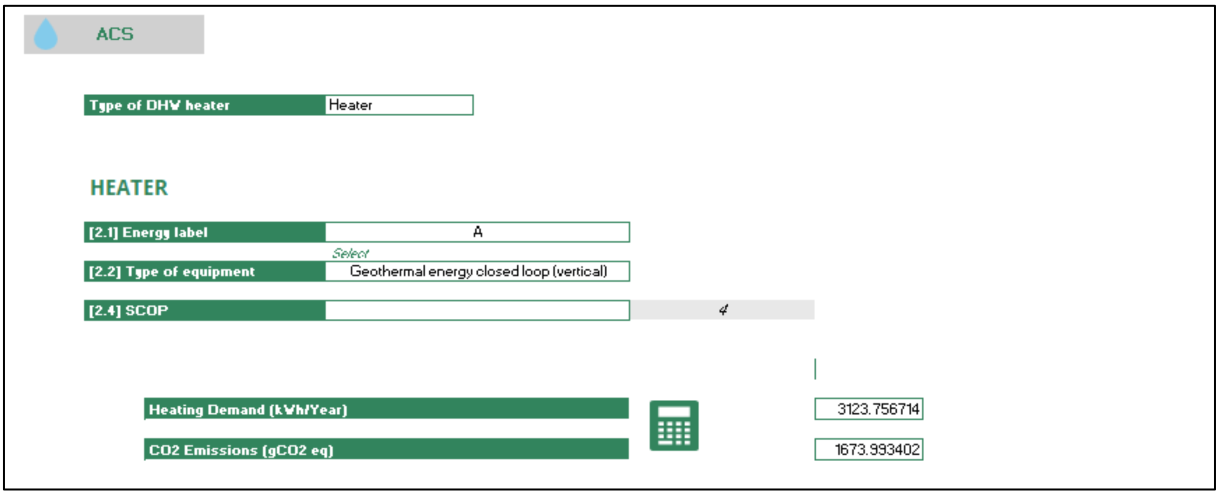


Figure 119. New heating, cooling and DHW system in Nisyros

Finally, the energy and emissions mitigation balance are as follows.

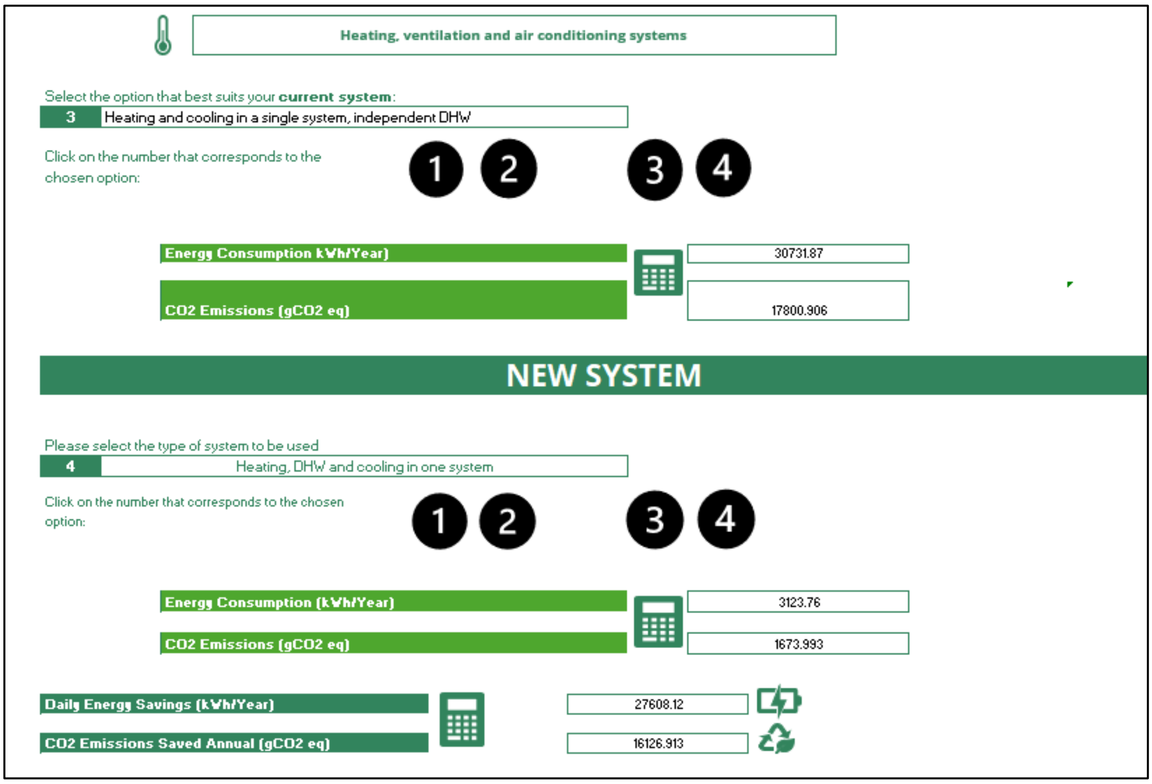


Figure 120. Energy savings and mitigation of air conditioning emissions in Nisyros

- **Introduction of renewable energies in public buildings**

Finally, it is proposed to introduce photovoltaic solar energy to provide electricity to public buildings.

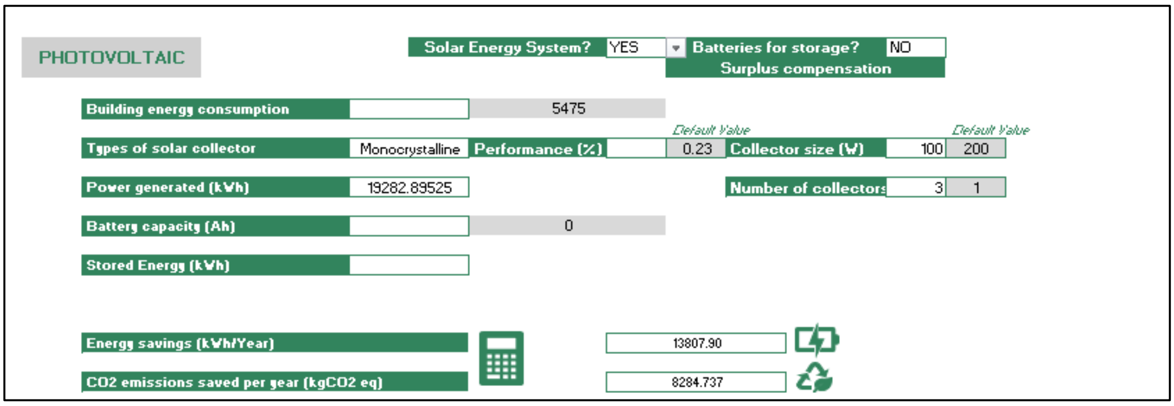


Figure 121. Implementation of photovoltaic solar energy in Nisyros

- **Replacement of vehicles with electric vehicles**

Finally, the possibility of replacing a conventional municipal vehicle with an electric one is also being considered.

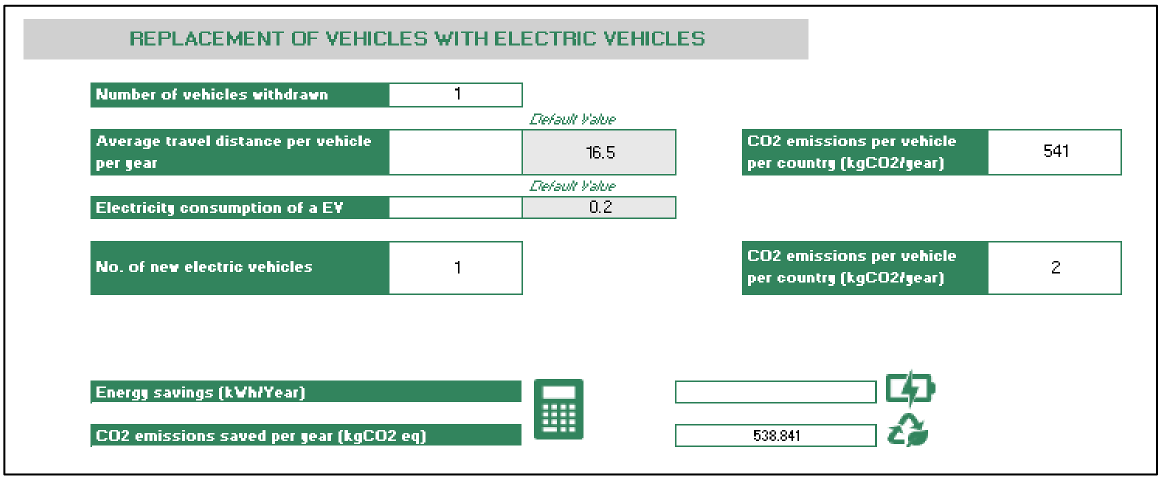
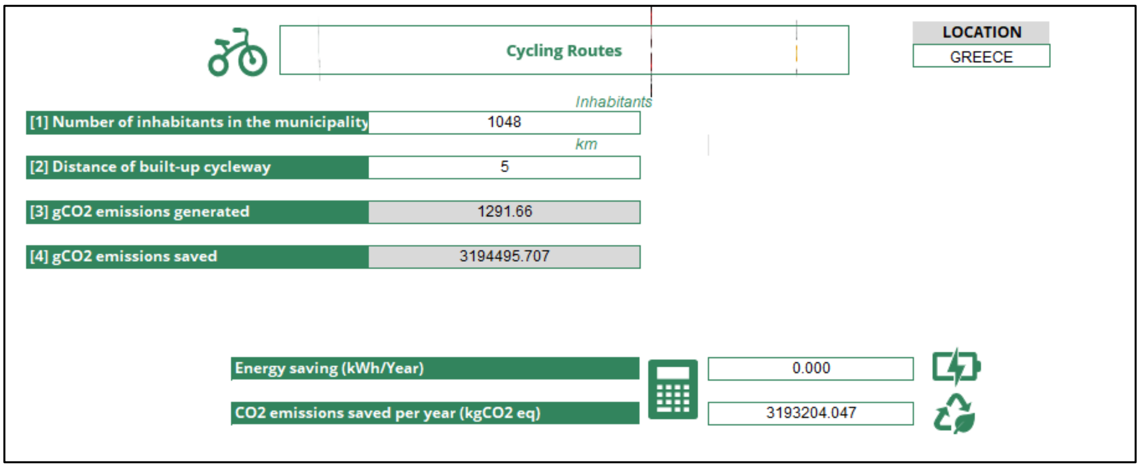


Figure 122. Introduction of municipal electric vehicles in Nisyros

Transport

- **Construction of cycling lanes**

In the field of transportation, measures are proposed to use bicycles and promote transport from the municipal level. Therefore, the creation of a bicycle lane is also proposed.


Cycling Routes

LOCATION: GREECE

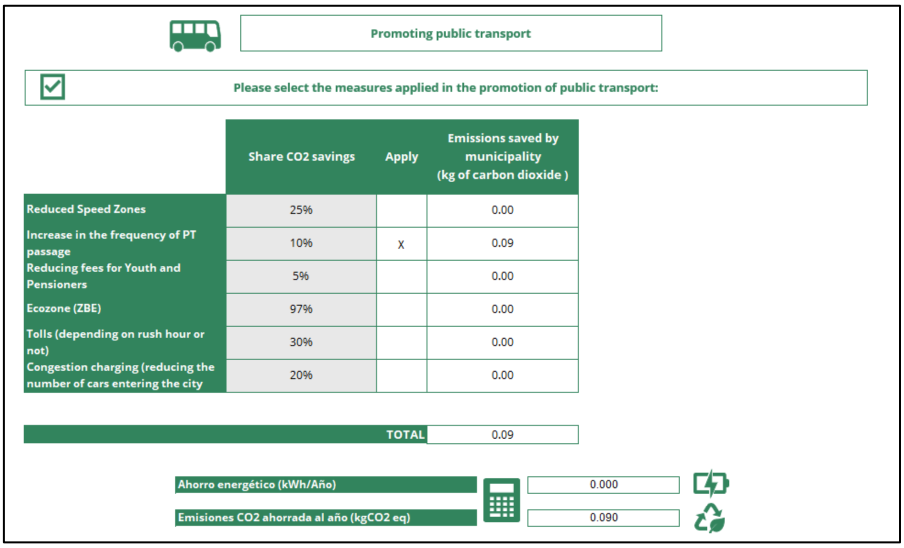
[1] Number of inhabitants in the municipality	1048	Inhabitants
[2] Distance of built-up cycleway	5	km
[3] gCO2 emissions generated	1291.66	
[4] gCO2 emissions saved	3194495.707	

Energy saving (kWh/Year)	0.000
CO2 emissions saved per year (kgCO2 eq)	3193204.047

Figure 123. Implementation of bicycle lane in Nisyros

- **Promotion of public transport**

Another measure in relation to public transportation is to increase the frequency of transit, thus encouraging its use and reducing emissions.


Promoting public transport

Please select the measures applied in the promotion of public transport:

	Share CO2 savings	Apply	Emissions saved by municipality (kg of carbon dioxide)
Reduced Speed Zones	25%		0.00
Increase in the frequency of PT passage	10%	x	0.09
Reducing fees for Youth and Pensioners	5%		0.00
Ecozone (ZBE)	97%		0.00
Tolls (depending on rush hour or not)	30%		0.00
Congestion charging (reducing the number of cars entering the city	20%		0.00
TOTAL			0.09

Ahorro energético (kWh/Año)	0.000
Emisiones CO2 ahorrada al año (kgCO2 eq)	0.090

Figure 124. Promotion of public transport in Nisyros

Awareness

The promotion of awareness-raising measures is essential to help the population become aware, get involved and reduce their energy consumption. For this reason, the municipality of Nisyros places special emphasis on taking environmental awareness measures.

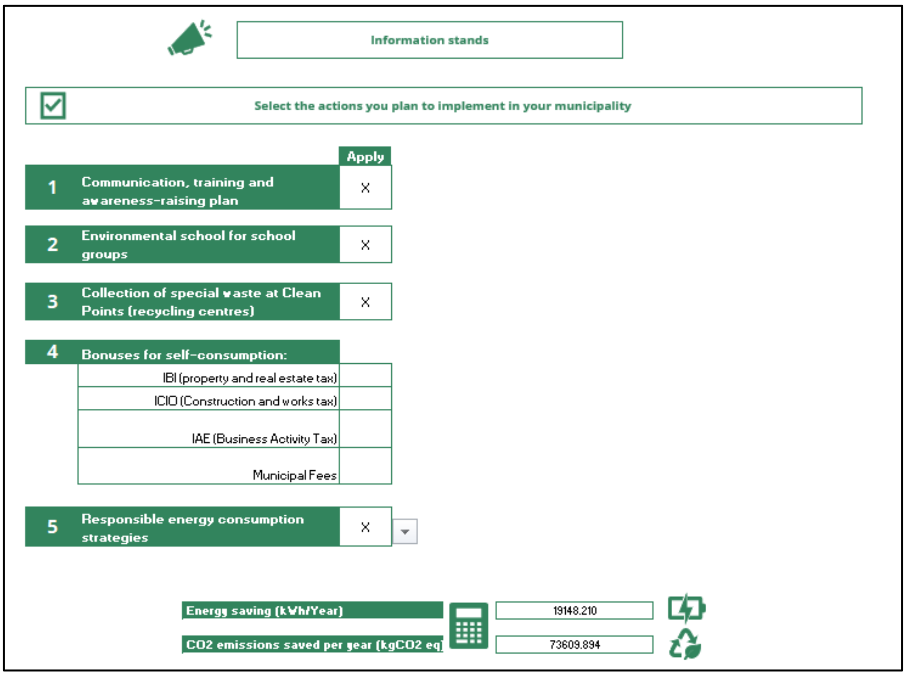


Figure 125. Citizen awareness measures in Nisyros

3.3.4.3. Multicriteria Decision in Nisyros

Considering the priorities established by the municipality, the criteria used to prioritize the different levels are as follows:

- Local production of electricity from renewable sources.
- Raising public awareness to reduce energy consumption at the municipal level, as well as reducing the use of oil.
- Improvement of the transport sector by reducing CO_2 emissions.

The assessments are introduced in the chosen software applying the AHP method and a final report is obtained, suitable for the municipality of Nisyros.

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	CA1.1 Improving the insulation of municipal buildings	0.0101	0.0303	0.0763	8
	CA1.2 Improvement of municipal lighting	0.0160	0.0484	0.1218	7
	CA1.3 Heating, ventilation and air-conditioning systems	0.0316	0.0953	0.2400	4
	CA1.4 Introduction of renewable energies and self-consumption	0.1317	0.3969	1.0000	1
	CA1.5 Municipal Transport Reposition	0.0060	0.0181	0.0456	9
	CA2.1 Industrial Process improvement	0.0029	0.0087	0.0219	13
	CA2.2 Renewal of industrial equipment	0.0027	0.0081	0.0204	14
	CA2.3 Improvement of Industrial buildings	0.0059	0.0178	0.0449	10
	CA2.4 Change of energy vector	0.0049	0.0149	0.0375	11
	CA3.1 Cycling Routes	0.0320	0.0966	0.2433	3
	CA3.2 Network of EV recharging points	0.0185	0.0559	0.1408	6
	CA3.3 Promoting public transport	0.0226	0.0682	0.1718	5
	CA4.1 Ecomovil	0.0045	0.0135	0.0341	12
	CA4.2 Information stands	0.0422	0.1273	0.3208	2

Figure 126. Report on alternatives obtained for the municipality of Nisyros

Finally, the ranking of the most valued alternatives taking into account the municipal casuistry is as follows:

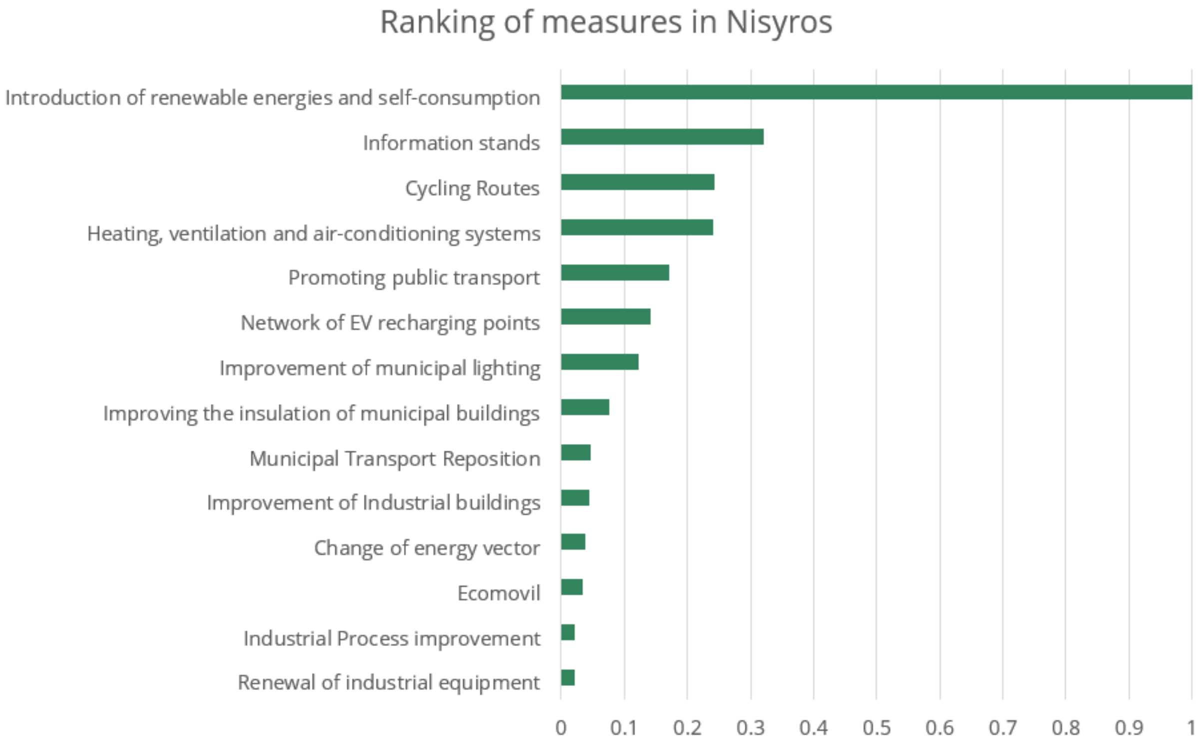


Figure 127. Ranking of most promising strategies for the municipality of Nisyros

3.3.4.4. Ranking of the most promising strategies in Nisyros

In summary, the most promising strategies for the municipality of Nisyros are presented. A table with the results obtained by implementing the GENERA tools is presented below:

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
1	Introduction of renewable energies and self-consumption	13.87	8.28	Municipal facilities
2	Information stands	0.73	2.81	Awareness
3	Cycling Routes	-	3.19	Transport
4	Heating, ventilation and air-conditioning systems	27.6	16.13	Municipal facilities
5	Promoting public transport	-	0.09	Transport
6	Network of EV recharging points	-	724.16	Transport
7	Improvement of municipal lighting	8.79	5.27	Municipal facilities
8	Improving the insulation of municipal buildings	-	-	Municipal facilities

PRIORITY	ACTION	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO_2e)	CATEGORY
9	Municipal Transport Reposition	-	0.54	Municipal facilities
10	Improvement of Industrial buildings	-	-	Industry
11	Change of energy vector	-	-	Industry
12	Ecomovil	-	-	Awareness
13	Industrial Process improvement	-	-	Industry
14	Renewal of industrial equipment	-	-	Industry
	TOTAL	**50.99**	**760.47**	

Table 13. Most promising strategies in Nisyros and estimated associated energy and emissions reductions

The most promising strategies for Nisyros focus mainly on improving municipal facilities, public awareness and transportation. Therefore, its main actions are awareness-raising, although it is also betting on local energy generation and energy efficiency.

3.4. Lessons Learned

This section introduces some ideas that have been compiled for each of the GENERA modules in order to improve the tool and make it more user-friendly for policy makers.

- Improvements in the **Energy Planning Module**:
  - It is proposed the possibility of introducing a national scenario based on the results and measures integrated in the municipalities and resulting in a more sustainable scenario.
  - Facilitate the input data to the tool, as the process can be complicated, e.g., searching for data in the International Energy Agency.

- Improvements in the **Inference Module**:
  - In this case, since these are pilots, standard measures have been implemented (municipal buildings in general), but it is proposed the possibility of introducing measures for each specific building and finally obtain the sum of energy savings and emissions.
  - The possibility of adding local energy generation actions is raised, studying better the different alternatives proposed by other municipalities and plans.
  - It is suggested to provide a method of data entry (units, how calculations are performed, etc.) to reduce time for unit changes and other needs that arise when entering information into the tool.
  - Specific improvement in energy efficiency in buildings: introduce measures targeting private buildings, as public buildings are considered to have mainly a direct impact. However, the option of private houses could be introduced, including a lower success rate.
  - It is important to introduce the idea of generating electricity at the level of energy community and housing supply, as it is proposed for public buildings but also for housing and energy communities.
  - In relation to the general structure of the tool, the option of dividing the measures into mitigation and adaptation in accordance with the guidelines of the Covenant of Mayors is proposed.

- Improvements in the **Decision Module**:
  - It is indicated that the time required to enter the information is high, so some simplification is appropriate.
  - It is important to reduce the number of indicators, as many indicate similar values or options (percentage of municipal RE and municipal RE production, etc.), which slows down the decision-making process.

- The possibility of implementing the AHP method in an alternative tool that allows the introduction of comparisons in a more dynamic way, as well as making changes in a more agile way, is studied. The use of the SuperDecisions software is a tedious computational process that requires a well-functioning computer.
- A proposal to improve the module is to activate and deactivate those actions not included in the municipal plans, since even though they are not included, they are assigned weights by comparison with other strategies. In this case, since there were not many actions included, although the process was tedious, it was feasible, but in the case of introducing many actions, the calculation time can be very long.

Overall, the results obtained are in line with expectations. This is the first version of the GENERA tool that includes three calculation modules together with the database of municipal actions. It is possible to introduce improvements and include options proposed in this document to achieve better results.

4. Conclusions

This section compiles the conclusions obtained after the completion of this deliverable, as well as of WP3 on the development of an energy transition tool aimed at municipalities and political decision-makers in the islands in particular.

After identifying a clear need to create tools aimed at municipalities to assist them in the creation of an action plan, GENERA has created a tool consisting of different modules that provides information at the national level and deepens not only at the local level, but also at the particular level of the current governance team. The possibility of including qualitative information provides a tool tailored to smaller municipalities.

The broad scope of the GENERA tool requires the management of many data: national (energy context), regional (municipal) and local (governance team). This gives very precise information about the context in which the municipality is framed and can help policy makers to have an overview of where the municipality wants to go with its measures.

The GENERA tool created and implemented in these pilots are intended to be user-friendly and easy to use, although improvements can still be implemented to facilitate their use and information visibility (see section on lessons learned). In addition, the idea of creating a manual to facilitate their use could also be considered.

This document is current evidence that a tool with these characteristics can be very useful for any policy maker, simple to use and with easily manageable information. The results provided are technically easy to understand and can be modified. It should be noted that these pilots could be more extensive and include an infinity of actions, but due to the limit of content it was decided to carry out a limited pilot per municipality, since the idea was to test its operation and results.

In essence, through the GENERA project, a tool has been created consisting of different modules that provide information on the ET status of different municipalities. This tool is specifically created to be applied in municipalities located in the countries of the project consortium (Greece, Italy and Spain). A pilot test has been carried out in different municipalities of tourist islands: Sant Antoni de Portmany (Ibiza, Spain), El Rosario (Tenerife, Spain), Stintino (Sardinia, Italy), Halki, Rhodes and Nisyros (Greece). From each of the pilots, a list of measures has been obtained according to the municipal casuistry and municipal needs, and energy savings and CO_2 emission reductions have been obtained. It is expected to improve and complete the action plans of these municipalities, collecting more information and applying it to other municipalities to continue progressing in the development of this tool.

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